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DEVOTED TO

INDUSTRIAL PROGRESS

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THE INDUSTRIAL PROBLEM IN AUSTRALIA.

By Edmund Mitchell, M. A.

IN no part of the world has the struggle between organized labor and organized capital been more severe, determined, and continuous, during the past five years, than in Australia. There has been no actual bloodshed, as in the case of the Homestead strikes in America; but there have been present most of the other elements of war,—bitter animosity, ceaseless vigilance engendered by mutual distrust, fierce recrimination, widespread distress and ruin, involving not merely the combatants but thousands of innocents as well. Besides skirmishes of minor importance, there have been four pitched battles, for the fighting of which all the resources of the opposing bodies have been concentrated. First the unionist miners in the coal district of Newcastle tried conclusions by declaring a strike; then the sailors and firemen threw up their work, and dragged into the dispute the wharf-laborers, gas-stokers, shearers, and other associated trades; next the shearers did battle on their own account throughout Queensland, New South Wales, and South Australia; and finally at Broken Hill, the last and best munitioned stronghold of the New Trade-Unionism in Australia, the Amalgamated Miners' Association rushed headlong into a fourth conflict with the employers.

It has to be noted that in no single instance did these disputes originate from or hinge upon a disagreement as to wages. Brushing aside a few minor issues involved, we find that the one cause of quarrel throughout was the demand on the part of the strikers for the exclusive recognition of unionism and the firm determination of the employers to refuse to concede that demand. Had the

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unionists won the day, there can be no doubt that every worker in Australia earning his living by the sweat of his brow would have been compelled to join one or other of the labor organizations and place himself under the domination of the small cliques of individuals in the big cities who make of labor agitation an exhilarating and lucrative profession. As it was, the employers were fighting with their backs to the wall, for the exclusive employment of trade-unionists involved the inevitable sequel of trade-union control of the workshops, factories, wool-sheds, steamers, and mines; therefore, every individual consideration had to be sunk in the combined determination to win. And they did win, leaving the trade-union bodies at present disintegrated, their accumulations of money dissipated, their leaders thoroughly discredited. The two main results brought about by the five years of incessant fighting count heavily against the trade-union organization. These are, firstly, vast combinations of employers prepared at a moment's notice to waive every selfish consideration and act loyally together as one man; and, secondly, a fixed determination among all classes of the community that the principle of freedom of contract, or the right of every man to earn his living whether he be a trade-unionist or not, shall be maintained at all hazards.

To show how thoroughly labor militant in Australia has forced employers to combine in self-defence, let me take the great wool-growing industry, which adds yearly to the wealth of these colonies from £20,000,000 to £25,000,000. The lethargy and lack of cohesion among the pastoralists enabled the shearers' union three years ago, to acquire a position of almost despotic power. Its leaders boasted that they controlled the shearing in 95 per cent. of the wool-sheds. In the framing of the rules which regulated in every detail the manner in which the shearing was to be conducted, the employer had no voice whatever; he had either to accept them or to enter upon the almost impossible task of fighting the whole union single-handed. Every shearer was compelled to take out his union ticket, paying, besides entrance fees, £1 per annum for the privilege; and the man who refused to submit to this black-mailing process was declared a pariah by whose side no unionist would work or eat, was hounded from wool-shed to wool-shed without the chance of securing employment, and was finally driven out of the industry. The weapon of the boycott was ruthlessly used against employers and non-unionist shearers alike, and some conception of the wide-reaching development of the system will be de-

SHEARERS' CAMP, CENTRAL QUEENSLAND.

rived from an extract from a manifesto issued by the shearers' union: "We intend," ran this official document, "to teach the squatter the folly of resistance to our combination. He shall not be allowed to shear his wool except by union labor. But if he should succeed in getting the wool off the sheep's back, it may rot in his sheds, for we shall prevent the carriers taking it to the railway; and should he succeed in getting it to the railway, we shall prevent it going to sea, for we shall call out the sailors and the officers; and if it sails, we shall prevent its discharge in London, for we shall call out the dock-laborers."

This announcement on the part of the trade-unionists of their deliberate intention to inflict a reeling blow upon the great staple producing industry of Australia for no more important reason than that a single back-block squatter might have refused compliance with the unionist demands was the death-blow to the New Trade-Unionism in these colonies. It effectually ranged public opinion upon the other side, and, when the actual attempt to enforce the threat was made, the shearers' union found itself face to face with a combination of pastoral employers infinitely stronger than that of the workmen. The lesson had been driven home to the minds of the pastoralists that employers, when taken in detail, fall an easy prey to organized labor, and that the only safety of each is the union of all. Despite the vast area of the Australian continent

and the isolated position of each wool grower, the movement spread from colony to colony, until in a surprisingly short space of time the combination of pastoralists had secured the control of not far short of one hundred millions of sheep. By combined action on the part of the pastoralists' association with the shipowners the attempted boycott on wool was broken down almost instantly, and every bale of wool sent forward was shipped with no appreciable delay.

The shearers' union leaders considered themselves repulsed but not beaten, however, and the very next season (1891) they engineered a strike of shearers throughout Queensland and New South Wales. The bitter and costly struggle thus initiated lasted over six months; but the pastoralists won the fight right from the commencement, for free laborers were poured into the districts where the unionists terrorized the local men from working, every sheep belonging to members of the pastoralists' association was shorn, and every bale of wool was carried to the ports of shipment. Admittedly the wool-growers took these lessons as to organization from the trade-unionists, and the latter were beaten at their own game.

The great shearers' strike of 1891 is typical of the labor struggles that have been going on in Australia continuously during the past five years, and the illustrations that accompany this paper will

FEDERATION STREET, STRIKERS' CAMP, QUEENSLAND, 1891.

ARMED NON-UNIONISTS, CENTRAL QUEENSLAND STATION.

serve to indicate the truth of my previous remark that, while there was no actual blood shed, there was a condition of real civil war. At Broken Hill, the greatest silver-mining center in the world, the campaign was conducted last year on very similar lines and with identical results. There was a complete absence of rioting on the Barrier, the crowds with which the mounted troops had to deal being as a rule as orderly as those which annually assemble to witness the trooping of the colors at the Horse Guards in London. But for all that the very worst features of the New Trade-Unionism were disclosed in all their repulsive nakedness during the progress of the Broken Hill strike. The leaders, who are now serving sentences in jail, showed themselves to be professional agitators pure and simple. Possessed of the gift of fluent speech, these men, not miners by calling at all, had foisted themselves upon the workers' associations, and, by the rhetorical trick of inflaming envious passions and stirring up strife between the employers and the employed, had soon attained to positions of personal ascendancy, the toleration of which among large bodies of fairly-educated, self-respecting workingmen is almost incredible. The strike was the very opportunity desired by the leaders. At one bound they became persons of public importance, issuing fierce manifestoes,

having their speeches telegraphed across a great continent, visiting their pickets like generals in the field, being huzzaed by the mob as they passed along the streets, and generally living in a constant vapor-bath of self-esteem and servile flattery. All these are simply the necessary preliminaries to securing a seat in Parliament and what to a man of the working classes is a very large income,—£300 per annum, with no real hard work to do, with free railway traveling and invitations to official dinners.

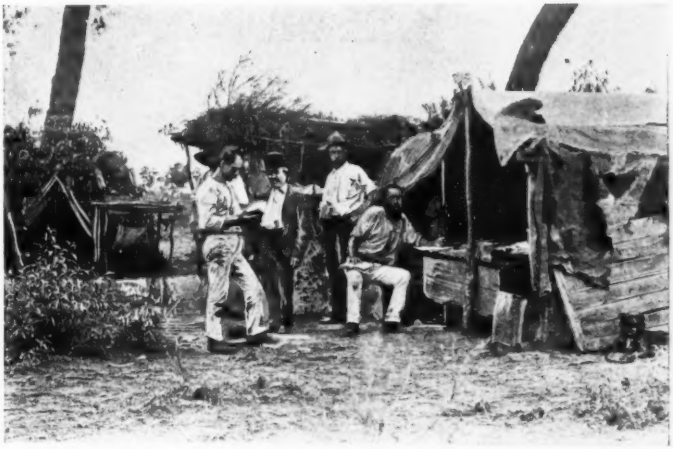
The real workers of the Barrier did not strike of their own free will; they were coerced into doing so by their leaders, who, as I

NINE-POUNDER GUN FOR PROTECTION OF NON-UNIONIST SHEARERS.

have shown, had their own private ends to serve, and who had at their beck and call a gang of about a thousand of the worst type of larrikins to be gathered together from all parts of Australia. The latter were men who had no honest desire for continuous work, who were not really miners by training, who had been forced upon the mining companies in the first place by the unionist tactics of threatening a strike if any refusal to their demands was made, and who were quite content to live in idleness for a few months at the cost of their fellow workers in the other colonies. Here is the whole secret of the Broken Hill strike, which has

caused such ruin among the homes of the resident miners, but which has had its good results in driving from the Barrier silver field the riff-raff whose presence was a constant menace to industrial peace.

Prior to this great series of strikes which began at Newcastle and terminated at Broken Hill, the unions were in a position in the various industries affected to compel the employers to employ only unionist workers. The abuse of this power, towards both employers and non-unionist workmen, was flagrant. The trade-unions in Australia had become small oligarchies of labor, appropriating all the wages paid in certain trades, excluding interlopers by a system



LIBRARY IN STRIKERS' CAMP, CENTRAL QUEENSLAND.

of prohibitive entrance fees, compelling employers to retain the services of inefficient or mischief-making workmen, and practically taking the whole control of each business out of its owner's hands. But in pursuing this utterly selfish policy the New Unionists over-reached themselves. At the moment of crisis their whole system broke down, for the men they had excluded from their ranks in time of peace stepped in and took the place of the unionist strikers in time of war. It afforded keen satisfaction to the able-bodied laborer, who for months before had vainly sought for work on the wharves of Melbourne, failing to get it simply because he was unable to pay the £5 entrance fee to the wharf-laborers'

QUEENSLAND BUSH WORKERS.

union,—to have a share of the loaves and fishes at strike time. The unionists on strike looked aghast at the spectacle of free laborers taking their places, and they reviled the new-comers as "blacklegs," "scabs," and "traitors." The truth is that the free laborers by their action helped to break up the most unscrupulous and selfish organizations that have ever brought discredit upon the noble cause of trade-unionism. The phrase "freedom of contract," which is purely of Australian origin in this application, having originated during the simultaneous maritime strikes in Melbourne, Sydney, Adelaide, and Brisbane, has now come to be, not merely the watchword of employers, but the charter of liberty for every workingman in these colonies. Workers have no longer to submit to being bailed up for their union ticket before they are allowed to handle a hammer or shift a sack of wheat. Employers are now free to engage their hands solely upon their merits as workmen, and quite irrespective of their being trade-unionists or not. In a word, public opinion demands that no man shall be refused the right to earn bread for his family and himself simply because, from poverty, conviction, or any other motive, he declines to join a trade union. If Unionism is ever to recover its lost position in Australia, it will have to accept, not reluctantly and sullenly as now

after bitter defeat, but fully and freely, the principle of freedom of contract. It will have to recognize that, if members of a trade-union have their rights, precisely equal rights are possessed by the men who refuse to surrender their individual liberty, except in so far as that individual liberty is restricted by the laws of the land, passed by the parliamentary assemblies elected to make those laws.

It is difficult to estimate the seriousness of the check that has been given to the development of Australia by the industrial unrest of recent years. Outside investigators, unfortunately, have not paused to reflect that the voice of the trade-unions, like the voice of the cicada, has been out of all proportion to the extent of their organization. It may surprise readers in America or Europe who have been following the labor question in Australia to learn that there are not more than 75,000 unionists in all these colonies. For this fraction of the working population to speak in the name of Australian labor is scarcely less absurd than were the three tailors of Tooley street, who began their famous document with the words: "We, the people of England." It is needless to deny, however, that outside Australia, and even within the colonies, the trade-unions, by reason of their public prominence, have come to be looked upon as synonymous with the working classes generally. The paucity of their numbers, and their antagonism to large sections of men who live by labor, show how mistaken is this notion.

Why, at this moment, in a country whose resources are inexhaustible, is it almost impossible to float public loans? Why has the establishment of new industries and the extension of existing ones been brought to a standstill? Why are millions of pounds sterling being deposited with the Australian banks for investment elsewhere, while the land is crying out for the fertilizing stream of capital? The answer is writ large upon the wall. Investors will not embark their money upon Australian enterprises so long as there exists no guarantee of industrial rest, no guarantee that at any moment contracts entered into will not be upset by a wanton strike, no guarantee that the blind policy of labor grappling at the throat of capital will be abandoned. In a word, the uncertainty of the labor question is paralyzing investment.

A few years of "booming" and wild speculation have been succeeded by the inevitable collapse and period of depression. The whole system of immigration has been misunderstood, and, instead of the new-comers being steadily directed away from the thickly

settled districts, as in America, in Australia the four chief maritime cities act as huge drag-nets, intercepting and retaining nine out of every ten new-comers. In consequence, these four centers hold about half of the entire population in each colony, and these armies of town-dwellers thus became comparatively useless manipulators of material already produced in a land where the undeveloped mineral, pastoral, and agricultural resources require every pair of hands that can be found. Without broaching the vexed question of free trade and protection, there can be no doubt that the protective policy of these sparsely populated colonies, directed towards encouraging city industries such as shoe-making, the

THE STRIKE AT BROKEN HILL.

manufacture of hats, and the turning out of slop goods, is a delusion and a snare. There is an area equal to an English county for every man, woman, and child in the Australias, absolutely unoccupied and undeveloped; yet we have Melbourne with a population of half a million souls, and Sydney almost as densely peopled, and in these cities we meet with poverty and distress and thousands of unemployed vainly seeking for work. Owing to this we find immigration to Australia inveighed against by the trade-unionists who are already in the country but who, remaining in the towns, have done little or nothing to develop its resources; and

we have even the astounding spectacle of the colonial representatives in London, the agents-general, warning off intending immigrants from a land teeming with natural wealth and capable of supporting, not the four millions of people that now dot its seaboards, but four hundred millions.

No amount of word-painting or piling up of statistics can give even a faint idea of the vast potential wealth of Australia. Full revelation only comes when one travels over the country, and, seeing in patches here and there what the soil is really capable of, finds the land a veritable wilderness with no sign of human occu-

GOING ON DUTY AT THE MINES, BROKEN HILL.

pation except for a few sheep fences. The scrub has only to be rolled, burned off, and tickled with the stump-jumping plow to produce harvests of wheat that cannot be beaten in any part of the world. The vast, perfectly flat area lying between the Murray and the Murumbidgee rivers has a soil rich as that of a garden, but it is given over to sheep, running about one to the two acres and producing about seven shillings' worth of wool per annum. In Queensland, upon the savannahs stretching hundreds of miles in every direction, the traveler rides or drives through natural herbage reaching to his buggy-poles or his saddle girths, and in a day's

journey sees only a few hundred sheep or a few score of cattle. The unbounded productiveness of these waste lands is proved by actual results. Australia can grow meat, butter, cheese, wine, fruit, and wheat for the whole world. From a few butter-factories in Victoria, for example, a single steamer has recently taken away £65,000 worth of chilled butter, and shipments are proceeding upon this scale weekly for three months each season, although it is only within two years past that the export trade in this article was commenced. Victorian brandy has been pronounced by the British medical journals to be equal in quality to the finest French cognac. The results already achieved show almost unlimited possibilities for wine-making in Australia. The fruit trade also has an infinite future, grapes, peaches, apricots, oranges, lemons, pears, apples, plums, pine-apples, and almost every other known variety capable of sea transport flourishing as in the sunniest corners of France, or Spain, or Italy. Then, even the already important pastoral industry is capable of expansion, for an immense area of country is still unstocked, and in the wool growing districts a system of small farming, with cereals and stock dividing the attention of the agriculturist, would vastly increase the productiveness of the sheep runs. The fattening of sheep and cattle for export in the frozen state to the markets of Europe is an enterprise as yet merely in its infancy. The primeval forests in many regions are

EDMUND MITCHELL.

rich in valuable timbers, but their silence is still unbroken by the ring of the woodman's axe. Instead of the three thousand camels now in use in the arid regions of central Australia there might be twenty times that number, opening up pastoral country as yet incapable of occupation through the impossibility of getting up station supplies, and enabling gold reefs to be worked where men cannot now subsist for scarcity of water.

Again, one has but to stand at Bendigo, or Ballarat, or Broken Hill, before the mountains of slag or quartz tailings, to realize that only a pinch of the mineral wealth in the bowels of the earth has yet been extracted. In Tasmania is the biggest tin-mine in the world, Mount Bischoff; in New South Wales the biggest silver-mine in the world, the Broken Hill Proprietary; in Queensland the biggest gold-mine in the world, Mount Morgan; in South Australia, one of the biggest copper mines, Moonta; around Newcastle, in New South Wales, among the most extensive coal measures anywhere to be found. And though hundreds of millions of pounds sterling worth of minerals have been raised in Australia, it is certain that thousands of millions remain to be won. Yet, despite the fact of an over-crowded old world, the flow of immigration to this great new world has all but ceased, and so far as population is concerned Australia, outside a few score of large cities and towns, is virtually a wilderness.

What these colonies want are population and capital; yet we find an utterly selfish growth of trade-unionism doing its utmost to check the inflow of both. "Australia for the Australians!" shout the men who are deliberately allowing harvests of untold wealth at their doors to lie ungarnered. If only the colonial governments would throw aside the last vestige of fear of the Trades' Halls; if only politicians could be found who would think more of the country's development than of the voters in their particular metropolitan constituencies; if only a race of statesmen were to arise who would resolutely burst up the city populations and take measures to pour a steady stream of immigration upon the soil,—then the progress of the Australias would amaze the whole civilized world. Perhaps the sovereign remedy will be found in Federation, which may give us, instead of half a dozen insignificant and time-serving legislatures, one thoroughly disinterested and representative Parliament, to whose service men of honor, education, and enlightenment, who too often shrink from contact with present parliamentary methods, will devote their lives.

A DECADE OF MARVELOUS PROGRESS.

By Richard H. Edmonds.

THE growth of a great country like the United States cannot readily be comprehended except by a study of the aggregate results of the progress of a stated period, say of ten or twenty years. Ten years is but a brief span in the life of a nation, but a study of the history of this country during the ten years ending with 1890 will reveal a growth and expansion that few persons otherwise would have any conception of. Any attempt to estimate the future growth of the country, or to set forth the possibilities of the present decade as indicated by the wonderful advances of the last, would produce statistics that would probably be thought to have come from the brain of a visionary enthusiast. Without venturing any forecast, therefore, an attempt to point out the progress made by the United States in some directions in the last decade may be of interest. From this may be shown what population and production and achievement will be reached in 1900 if the rate of progress maintained from 1880 to 1890 should continue to the end of the century, leaving to the readers of THE ENGINEERING MAGAZINE the privilege of judging whether our national progress will go on at a slower rate or as rapidly as in the past.

In 1880 the population of the United States was 50,100,000; in 1890, admitting the census reports to have been correct, 62,500,000 people lived under the protection of the stars and stripes. The rate of increase was 24.8 per cent. The fact that this was less than for any previous decade in this century caused many to believe that the figures were too small, but, taking it for granted that these figures approximate to correctness, we added to our population in ten years 12,500,000 people. What this means can be best understood by means of comparison with the population of the leading cities of the country in 1890, which was as follows:

Cities.	Population.	Cities.	Population.
New York	1,515,000	Milwaukee	204,000
Chicago	1,099,000	Newark	181,000
Philadelphia	1,046,000	Minneapolis	164,000
Brooklyn	806,000	Jersey City	163,000
St. Louis	451,000	Louisville	161,000
Boston	448,000	Omaha	140,000

Baltimore	434,000	Rochester	133,000
San Francisco	298,000	St. Paul	133,000
Cincinnati	296,000	Kansas City	132,000
Cleveland	261,000	Providence	132,000
Buffalo	255,000	Denver	106,000
New Orleans	242,000	Indianapolis	105,000
Washington	230,000		
Detroit	205,000	Total	9,200,000

Thus the increase in our population between 1880 and 1890 as shown by these figures was 3,300,000 greater than the combined population of every city in the United States of more than 100,000 population.

Wealth increased during the decade even more rapidly than the population. It was a period of such gigantic railroad and industrial developments as to have furnished a foundation for the vast gain reported by the eleventh census in the assessed and the true valuation of our property. The assessed value of property in 1890, excluding all railroad property, except in a few States in which it was impossible to separate the latter from other taxable property, was $24,651,585,465, against $16,902,993,543 in 1880,—a gain of $7,748,000,000, or 45.84 per cent. The true valuation of all property in the United States in 1880 was $43,642,000,000. Should it be found upon completion of the census inquiry in relation to the true valuation of property that the same relation existed in 1890 between the assessed valuation and the true valuation as existed in 1880, the absolute wealth of the United States in 1890 was about $63,648,000,000, or a gain of $20,000,000,000 in ten years, not counting the increase in railroad property.

Nothing else tells the story of the marvelous progress of this country between 1880 and 1890 so well as the statistics of our manufacturing and mining interests. In the magnitude of our manufactures we now lead the world, and the annual value of the output of our factories far exceeds the aggregate value of all our farm products. The exact figures are not yet obtainable, as the census report on manufactures has not been completed, but in a recent interview Mr. Robert P. Porter, superintendent of the census, gave approximate estimates. These show that the gross value of our manufactured products during 1890 were about $8,600,000,000, against $5,300,000,000 in 1880,—a gain of $3,300,000,000. The capital invested reached $4,600,000,000, against $2,700,000,000 in 1880. The increase between 1880 and 1890 in the capital invested in manufactures was greater than the entire capital so invested in 1870.

In ten years we added to our manufacturing capital $1,900,000,000, while only twenty years ago—or in 1870—the aggregate manufacturing capital of the country was $1,690,000,000. The wages paid to the employés in manufacturing establishments in 1890 were nearly $1,500,000,000, or $500,000,000 more than in 1880. The number of hands employed increased 900,000 during the decade, so that in 1890 there were 3,600,000 people on the pay-rolls of our manufactories.

If the details of our manufacturing progress be examined, it will be found that there has been a well-rounded growth. Every branch of industry has made large gains. In cotton, in wool, in iron, in lumber, and in all industries using these staples as raw materials, there has been a wonderful advance. The increase has been in the small and large industries alike. We are making more pins and tacks and building more great steamships; we are making more coarse cotton and woolen goods and producing more fine cloths and silks. Every branch of industry that comes between these extremes has grown proportionately. In 1880 the iron-makers of the United States produced 3,781,000 tons of pig-iron, and, as that was a gain of nearly 100 per cent. over 1870, it was regarded as a rapid growth. In 1890, however, they turned out 9,579,000 tons, or a gain of over 150 per cent. in ten years, the total for 1890 being more than 2½ times as great as that of 1880. The actual increase in 1890 over 1880 was 2,000,000 tons greater than the total production in 1880. The 7,100,000 tons of iron ore mined in 1880 increased to 14,500,000 tons in 1890. The total production of all kinds of steel in 1890 was 4,466,000 tons, against 1,100,000 tons ten years before. In 1880 we made 740,000 tons of steel rails, and in 1890 we made 2,036,000 tons. The capital invested in woolen factories increased from $159,000,000 in 1880 to $296,000,000 ten years later.

Keeping pace with manufacturing growth, the mining interests of the country turned out $656,600,000 of products in 1890 against $369,000,000 just ten years before. This gain touched every branch of mining; the production of coal rose during the decade from 63,800,000 tons, valued at $95,600,000, to 140,700,000 tons, valued at $176,700,000; copper from 60,000,000 pounds, worth $11,500,000, to 265,000,000 pounds, worth $30,800,000; petroleum from 26,200,000 barrels, worth $24,000,000, to 45,800,000 barrels, worth $35,000,000; and silver from 30,300,000 ounces to 54,500,000 ounces.

Railroad construction progressed rapidly during the decade. It

is difficult to realize that, whereas we now have 170,600 miles in operation, we had only 93,200 miles in 1880. At the end of 1890 we had 166,700 miles,—a gain of 73,500 during the decade, or about 80 per cent. Thirty leading roads, which operated 31,500 miles of track in 1880 and hauled 96,000,000 tons of freight, in 1890 opeerated 76,400 miles and hauled 262,900,000 tons. The number of passengers carried by these roads increased from 58,400,000 to 183,000,000. The number of locomotives on all the roads in the United States increased from 17,900 in 1880 to 32,200 in 1890, and the number of passenger-, freight-, and baggage-cars from 556,000 to 1,092,000. The capital invested in railroads as represented by bonds and capital stock was a little less than $5,000,000,000 in 1880, and a little less than $10,000,000,000 in 1890.

In the decade under review a new industry of vast magnitude was created. Twelve years ago electricity as applied to street-cars, for power purposes of all kinds, for house and street illumination was a new thing. In fact electric street-railroads have only been in successful operation about half of that time. The electrical age was practically just commencing, and the aggregate capital invested outside of telegraphy was small. Now almost every town of any size has its electric railroad, streets everywhere are being lighted by electricity, and electricity furnishes power for factories, to run elevators, and for many other purposes; still we have scarcely seen the beginning of electrical development. Already, however, the capital invested in all branches of this industry—and nearly all invested since 1880—is estimated at $800,000,000.

Our national banking capital increased from $467,000,000 in 1880 to $662,000,000 in 1890, and the deposits in savings-banks from $819,000,000 to $1,550,000,000.

Agriculture is supposed to be the foundation of our progress and prosperity. This is to a large extent true, and yet, while the value of our manufactured products in 1890 was $8,600,000,000, the total value of all agricultural products in that year was only about $3,800,000,000. The opening up of new land by the heavy immigration into the West brought into cultivation ten or more years ago a larger area than the consuming power of this country, and the foreign demand added, justified. In a pamphlet recently published by Mr. C. Wood Davis, it is shown that the area cultivated in staple food-crops increased from 1875 to 1880 on an average of 6.8 per cent. a year, and since then has steadily declined, having been 3.9 per cent. from 1880 to 1885 and then 1.4 per cent.

from 1885 to 1890. In other words the total cultivated area is now increasing much less rapidly than our population. Of course in view of this the agricultural productions of the country do not show any such phenomenal advance as has marked the growth of industrial interests. The total value of all agricultural products in 1880 was estimated at $3,700,000,000. Mr. James R. Dodge, the statistician of the Agricultural department, estimated the value in 1890 at $3,800,000,000,—a gain of $100,000,000,—notwithstanding a heavy average decline in price and very short crops, owing to bad weather. In 1891 large crops brought the total value up to $4,500,000,000. The number and value of farm animals increased very heavily during the decade, the total value having been $1,576,000,000 in 1880 and $2,418,000,000 in 1890,—a gain of $840,000,000.

The facts which have been presented are simply intended to give some conception of the actual progress of this country. The magnitude of its advancement can only be realized when, as we have already said, we sum up what has already been accomplished in a brief period of ten years. To attempt to go into the details of this progress, to show the growth of every branch of industry, to point out the special enterprises of great magnitude that have been undertaken, to name even the most noted of the magnificent winter- or summer-resort hotels costing upwards of $1,000,000 each that have been built at St. Augustine, Tampa, and elsewhere, would be unnecessary in such a paper as this, and yet they all help to impress upon the mind the results accomplished in ten years.

Is there a single good reason why the decade that will end with 1900 should not witness even greater achievements and progress than were seen between 1880 and 1890? There would seem to be none. Wars or pestilences or panics may come, but this country grows right along. They may cause a temporary halt, but that seems only to serve as a resting-spell, to be followed by a still more rapid advance. Our national progress has gone on at a steady rate for many decades, and it is only the magnitude which our population and wealth and business have now reached that makes the statistics that picture the difference between 1880 and 1890 seem so overwhelming. We know that our population increases at an average of about 25 per cent. or over every ten years, that our production of iron has more than doubled every decade since 1840, that our wealth is annually increasing at a rapid rate; we know that we are developing a fine navy, that we are building up an immense domestic shipping business, having now in our

lake and coastwise trade 25,540 vessels valued at $215,000,000, which carried in 1890 over 172,000,000 tons of freight; that the beginning has been made in a revived foreign mercantile business, with the letting of contracts for five steamers to cost from $8,000,000 to $10,000,000, and to equal the *Paris* and the *New York*; that within the last few years there have been built the $5,000,000 shipyard at Newport News, the $6,000,000 combined iron- and steel-works and shipyard at Baltimore; that the chief shipyard at Philadelphia is largely the result of development of the last five or six years; that a number of large iron and steel shipyards have been started on the lakes within the last few years, the details of which were so entertainingly set forth by Mr. Henry A. Griffin in THE ENGINEERING MAGAZINE last month. These things we know, and we know that they all point to a broader and more rapid national growth than we have yet seen. An honest investigation will convince even the most confirmed pessimist that our country is advancing in material progress, and also in the arts and sciences, as never before. What amount of development then may we reasonably look for during the present decade? Starting in 1890 with a population of 62,500,000 and allowing for the average increase which has prevailed for a number of decades of about 25 per cent.,—never but once less than that, and then 24.8 per cent.,—it will be seen that in ten years there will be added 15,600,000, giving us in 1900 a total population of 78,100,000. To fully appreciate the magnitude of this gain in population it may be compared with the population of the Southern States in 1890 as reported by the Census:

States.	Population.	States.	Population.
Maryland	1,042,000	Kentucky	1,858,000
Virginia	1,655,000	Tennessee	1,767,000
West Virginia	762,000	Alabama	1,513,000
North Carolina	1,617,000	Mississippi	1,289,000
South Carolina	1,151,000	Louisiana	1,118,000
Georgia	1,837,000		
Florida	391,000	Total	16,020,000

Thus, omitting Texas and Arkansas, 16,000,000 people lived in the South in 1890, which is but a little more than the actual increase in the population of the United States will be in ten years. Expressed in another way, this increase is equal to the combined population of all the cities and towns of over 8000 population in the United States, excepting New York and Chicago. The total

urban population, including these two cities, in 1890 was 18,200,000 The increase already mentioned will be about 15,600,000, or only 2,600,000 less. But as the desirability of limiting immigration is being discussed, it may be claimed that the rate of increase will be less if this be done. Suppose immigration should be absolutely stopped, which is not probable, even then our gain would be about 11,000,000 or 12,000,000,—enough certainly to satisfy our national pride. What this means in city development, in increased demand for all manufactured and farm products, for enlarged railroad facilities, and in fact for everything which tends to national progress, can only be understood by remembering what was required and what was accomplished during the decade between 1880 and 1890.

In the material progress of this country as marked by the production and consumption of iron and steel there is an accelerating rate of growth. The consumption of iron not only increases with the increase in population, but the rate of consumption *per capita* has steadily increased for many years. Should the rate of gain between 1890 and 1900 be as great as between 1880 and 1890, the production of pig-iron in 1900 would be 24,200,000 tons. Should the actual increase in tons only be equal to the actual increase in 1890 over 1880, the total output in 1900 would be 15,370,000; basing their calculations upon the average rate of increase in iron consumption for the last forty years, the Hon. Abram S. Hewitt and Mr. Edward Atkinson estimate that the production of pig-iron in this country in 1900 must be from 17,000,000 to 19,000,000 tons. The 24,000,000-ton figure will probably not be reached. It is scarcely in the range of possibilities that our production should attain to that point this century, but that it may reach Mr. Hewitt's estimate of 17,000,000 tons is quite probable. We cannot add 80 per cent. to our railroad mileage as we did from 1880 to 1890, but it is possible that we may build 70,000 miles, as we did in that period, and we are almost certain not to build less than 50,000 miles. Even this latter figure would give us about 220,000 miles at the end of this century.

There is certainly no decline in the rate at which we have been increasing our wealth as compared with the previous decade, and as we gained nearly $8,000,000,000 in assessed valuation and about $20,000,000,000 in true valuation, it is quite certain that at least as much more will be added to our national wealth before 1900, with a reasonable probability of the increase being much more.

The United States is now the leading manufacturing country in the world. We have far outstripped all other nations in the magnitude of our industrial operations. It is almost incomprehensible that in ten years the increase in capital invested in manufactures should exceed the total invested only twenty years ago. The value of our manufactured products increased about 60 per cent.; add 60 per cent. to the output of 1890, and we would have $13,700,000,000 in 1900: but that is too much to expect. The same rate of growth in mining interest in this decade as in the last would make our mineral output in 1900 nearly $1,200,000,000, while a smaller percentage of gain, only equalling in volume the total increase in 1890 over 1880, would bring the figures to over $950,000,000. If our coal-miners add to the output of 1890 as many tons as they added to that of 1880, ignoring in this the percentage of growth, 217,000,000 tons will be the production of 1900. No other country in the world ever advanced in population and wealth as the United States is doing. The progress of the past shows no signs of halting. In fact, the development of our foreign and domestic trade and commerce and of our industrial interests is steadily broadening out.

Contrast our position and condition with Europe. With resources surpassing those of all Europe; with wealth-creating possibilities in soil, minerals, timber, and climate unequalled by Europe, and practically without limit to their profitable utilization; with a homogeneous population of 65,000,000 people unvexed by the arbitrary regulations of half a dozen different governments and free from the drain of standing armies,—the United States justly commands the wonder and admiration of the world. Great Britain is no longer the manufacturing center of the world, for we have taken the foremost position in that line. Its vast iron and steel business is yearly increasing in cost of production, while ours is decreasing. It cannot meet the world's growing demand for iron and steel, because it cannot increase its production to any great extent. It produces less pig-iron now than it did ten years ago. Much of its ore it imports from distant countries. Its cotton is all imported. It spends about $750,000,000 a year for foreign foodstuffs. On the continent every nation is burdened with debt, and none of them can ever hope to pay off its obligations. Measured by their natural resources and advantages for continued growth against their debts and the many disadvantages under which they labor, they are practically bankrupt. In all of them the cost of production and of living must steadily increase. In the United

States we have scarcely laid the foundation for our future greatness. In natural resources we are richer than all of Europe; we are paying off our debts faster than they are due, we have barely scratched the ground in the development of our mineral wealth, and our agricultural growth can scarcely be limited.

This paper was not intended as a logical discussion of the future based on the results of the past, but was simply designed to bring together a few of the facts which enable us to understand something of the amazing progress of this country, and thus, seeing what we have done, speculate in a general way on what will be accomplished before the end of the nineteenth century. We have a country of boundless natural resources, the greater part of which is comparatively thinly-settled. There is unlimited room for expansion. New railroads can be built in many sections and find profitable business awaiting them; new mineral districts as rich as the best now being developed invite capital and energy; irrigation is making fertile great areas of Western land that were before worthless; in the Northwest and on the Pacific coast there is a marvelous advancement; the South alone has sufficient area and natural advantages to support a larger population than that of the whole country at present, and the development of that section will furnish a profitable opening for the surplus money of the East; the growth in our commercial relations with South America and the West Indies brings into action new forces that tend to the upbuilding of this country; the completion of the Nicaragua canal will mark the beginning of the most active era in our commercial and industrial history and revolutionize the commerce of the world in our favor. History affords nothing with which to compare our marvelous advancement. And yet, amazing as has been the progress of the last ten years, the coming ten will show a still greater advance.

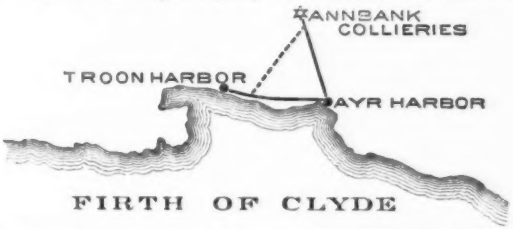
ENGLISH AND AMERICAN RAILWAYS.

A COMPARISON AND A CONTRAST.

By William M. Acworth.

FIRST PAPER.

WHEN the invitation to contribute these articles to THE ENGINEERING MAGAZINE reached me, I was stopping at a country house in Scotland, close beside a newly-constructed railway, and it occurred to me that I could hardly adopt a better method of drawing the attention of American readers to the enormous difference between our railways and theirs than by describing this little line—it is scarcely more than three miles in length—in some detail. The reason for the existence of the line, in itself instructive, will be clear to any one who will glance at the accompanying plan, on which it is indicated by a dotted line. Annbank collieries, which are close to the Firth of Clyde, have been accustomed to ship their coal at the harbor of Ayr. A few miles along the coast is a rival harbor at Troon, which naturally enough wanted a share in this trade. For this purpose it was evident that the railway rate to the two ports would need to be the same. But if the coal were sent by the existing railway through Ayr, and then along the coast to Troon, the same rate being charged for the whole twelve miles as for the first five only, it was likely that the Railway Commissioners would hold that an illegal preference was given to Troon. So the railway company was induced to construct a new



direct line, avoiding the Ayr *détour*. This new line is single-track throughout; there is no station on it; no passenger trains are run over it. Half-way along it there is a siding, at which coal and manure can be delivered to the adjacent farms, and milk, potatoes, and other produce received from them.

And this is how the line is constructed. At either end there is a signal-box, built to control the junctions with the old lines. The capital cost of these two boxes, which are only open during the day, we may reckon at about £250 apiece; and they cost about £100 each per annum for wages and general maintenance. Needless to say, all the switches and signals are interlocked, and equipped with facing-point-locks, rising-bars, and all the other elaborate machinery so dear to the soul of our English inspecting authority, the Board of Trade. The very manure-siding is furnished with derailing switch, facing-point-block, and ground-disk signal,—what Americans, I believe, call a "switch target," except that our ground-disk is lighted after dark,—and a tiny signal-cabin has been erected to contain the necessary levers. Yet further security is afforded by the fact that the line is worked on the staff-system,—in other words, no train may pass over the line, even though the signals are all right for it to proceed, unless the engine-driver is in possession of a staff, of special color and shape, which, being the only one in existence, assures him that no other train can be on the line at the same time. As for the road itself, in its entire length there is not a single grade-crossing. In their place there are fifteen over- and under-bridges, some built in solid masonry thoughout; others with steel girders laid on masonry abutments. The bridges are all constructed of sufficient width to allow of the doubling of the track hereafter if necessary. The right of way, some 70 feet wide, is fenced off on either side by a stout wire fence four feet high. The new steel rails, 90 pounds to the yard, are supported on chairs weighing 44 pounds each, fastened down to the ties—"sleepers" we call them—with four spikes apiece. There are eleven sleepers, 9′ 10″ by 5′ and creosoted, to each 30-foot rail; and they rest on two feet of broken-stone ballast. Heaps of furnace-ashes, lying here and there along the line, show that, when the stone ballast has had time to consolidate, it will have a top-dressing of cinders to make everything tidy. In fact the line is in all respects up to first-class main-line standard, and fit for the passage of passenger expresses at sixty miles an hour.

"What did it cost?" will be the natural question. In round figures, it may be said, £33,000, or £11,000 per mile. In other words, a line constructed to carry a minimum quantity of goods and mineral traffic—for the average at present is less than two trains each way per diem—through a flat agricultural district, has

cost as much as an average mile of railway in the United States. If our cheapest possible line costs so much, no one who knows England, who has appreciated from personal observation the vast preponderance of main lines and of railways in thickly populated districts with two or even four tracks over mere single-track country branches, will be surprised that our railways taken all round have cost about four times as much per mile as those in America. But I may be asked where the whole of the £33,000 went to; and perhaps it is worth while to answer in a little more detail. Roughly speaking, the contractor, who finished the road up to formation level, got £18,000; the railway company supplied and laid the permanent-way itself, at a cost for labor and materials of about £7000; the balance of £8000 represents the price of the land,—about twenty-nine acres at a little under £300 per acre. The value of land in the vicinity of the line may be quoted at £80 an acre; and yet the company voluntarily agreed to pay at the rate of £300. How much of this excess represents fair compensation for damage done to the adjacent farms by the intersection of the fields; how much is really consideration to the landowners to induce them to refrain from opposing the construction of the line, is a question that neither I nor anybody else can answer. But the difference between £80 and £300 represents, I think, fairly enough the average difference between the price of land to an ordinary purchaser and to a railway company. Attempts have been made more than once to enable railway companies in condemnation proceedings to set off the benefits likely to accrue to a landowner from the construction of a line against the value of the property which is taken for the purpose, but it is now settled by law that such set-off cannot be pleaded.

The price of the permanent-way needs no special comment. As to the contractor's account, it is perhaps worth while stating that railway engineers estimate that a bridge carrying a public road over the line costs on the average about £800 for construction, *plus* £600 for the approaches. Reckoning interest and maintenance at 5 per cent. on this sum, such a bridge costs, therefore, £70 per annum. Now, a new railway cannot be built to cross a public road on the level without special parliamentary sanction, which is rarely given except under very extraordinary circumstances. Even then the company is compelled to maintain gates at the crossing, with interlocked signals, and with a gatekeeper in constant attendance. This expense cannot be estimated at less than £70 per annum. It is

consequently as cheap for a company to build a bridge as to maintain a level-crossing.

I think I am right in laying stress on heavy cost of construction as the most prominent characteristic of English railways, more especially when compared with those of the United States. How far the engineers and the public respectively are responsible for this expenditure, a good deal of which is certainly without economic justification, is a question very much harder to answer. No doubt our engineers have been encouraged to be extravagant. Capital in England has been abundant these last fifty years. The great railway companies could raise £100,000,000 per annum for years to come without the slightest difficulty in placing their shares. Again, it is always pleasanter for a workman who takes pride in his work to finish everything off in the best possible manner, and not to spoil the look of it with makeshifts. Further, a line thoroughly substantially built at the outset is cheaper to maintain than a line on which money has been grudged to start with; and the engineer knows that, while the capital outlay is disposed of once for all, the maintenance charges will be brought up in judgment against him year after year.

All these considerations doubtless have had weight in making our engineers, if I may so express it, extravagant-minded; but I venture to believe that the influence of the whole of them put together has been almost nothing as compared with the influence exerted by outside pressure.

American railways have been constructed, almost at their own unfettered discretion, by engineers working for a public to whom railways were an absolute necessity, and who were ready to take with gratitude a railway of the most imperfect description rather than be left with no railway at all. American companies have found it difficult enough to raise even the minimum capital necessary to construct their lines. Had the public there been as exacting as ours, and had it been able to enforce its views through the action of a department of the Government like our Board of Trade, it would never have got any railways at all. To say that England could have done without railways altogether would of course be ridiculous, but at least they were not and are not for us so absolutely essential as they were and are in the United States. To-day many people think new railways to be wholly unnecessary in England, for, though for years past railway construction has been almost stationary, we have to-day three times as many miles of line per square

mile of area as the United States has. Even at the beginning our people were not wholly dependent on the railways. We had an admirable system of roads throughout the length and breadth of the country; we had many thousands of miles of canals and navigable rivers; and further, no inhabitant of the United Kingdom was more than about sixty miles from the sea. Consequently railways would never have been suffered to exist at all in this country, had they been as reckless of human life and as careless of the inconvenience they inflicted on individuals, as American railways have been and to a great extent still are. An Englishman can only stare with astonishment, when he sees for the first time trains running through crowded streets of cities such as New York and Chicago. I have a vivid recollection of watching long trains of freight-cars running down the Tenth avenue in New York, to the New York Central's depot, in one of the busiest parts of the city. As I looked, I remembered that our most powerful company, the London and Northwestern, tried in vain for three years to obtain permission to move one truck at a time by horse-power across a narrow street in a very quiet parts of London, in order to connect together two different part of the company's own property.

Again, one reads week after week in American newspapers accounts of accidents in which passengers lose their lives. The American public seems to take it as a matter of course that such things must happen. In England, on the other hand, a serious accident excites a disturbance which does not die down for many weeks afterwards. In the year 1891, out of 900,000,000 passengers, precisely five lost their lives by accidents to trains of all sorts and kinds. In the autumn of last year there was, after an interval of two years, a serious accident,—that at Thirsk,—which resulted, I believe, in about a dozen deaths. Thereupon the following resolution was passed, not by a young ladies' debating-society, but by an assemblage of hard-headed men of business, the Wakefield Chamber of Commerce:

> In view of the large number of railway accidents that have in recent years occurred to passenger trains in consequence of goods-trains being run on passenger lines, the time has arrived when Parliament should compel all companies to provide a separate set of lines to be used exclusively for goods traffic on main lines, and under no consideration should goods-trains be allowed to cross or be shunted on any portion of the main passenger lines, and such lines should be used exclusively for passenger-train service.

Such being the state of public opinion, it is perfectly impossible

for the railway companies to disregard it. No company could expect to obtain parliamentary sanction for the construction of a new line of anything but first-rate quality in all respects. Nor, when the line was built, could it obtain the sanction of the Board of Trade to the opening, unless the stations, the points and crossings, the signalling appliances, the engines and rolling-stock, all conformed to what I may call an ideal standard of safety. Yet again, if the line were not kept up to the same standard when opened, public opinion, taking one day the form of public rebukes from the Board of Trade, another day of questions and discussions in Parliament, or again of exemplary damages awarded to passengers injured in accidents, would soon compel the company to realize that lavish expenditure was after all the truest economy. But perhaps this point has been labored overmuch. I am anxious, however, that American readers should appreciate that the enormous cost of construction and working of English railways is due not to any single and remediable cause, but to a whole series of national tendencies and characteristics, acting over long periods of time and only to be changed very gradually, if at all.

Now let us turn to another point. The very large capital outlay of English railways is of course one main reason of the high standard of rates and fares in England. Exactly how high that standard is we have no means of knowing, for our railway statistics, made up in a form that was laid down by act of Parliament about thirty years back, carefully suppress the information that it is most necessary for us to have. Ton-miles and passenger-miles are not here recorded. We know that each ton of goods carried pays the railways on the average about 60 cents. If we guess that the average distance is about 25 miles, we arrive at an average rate of 2.40 cents per ton-mile, which is not very far from three times the average rate in the United States. So in the case of passengers we may guess that the average fare is about 1.75 cents per mile, which, though lower than the American average, is higher than in any European country. Such a result seems very far from satisfactory. High cost of oonstruction might have justified a high range of rates and fares at the outset, but year by year the traffic per mile of line open increases in density, and yet the goods rates hardly come down at all,—in the last year or two their tendency has been all the other way,—while the passenger fares only come down very slowly. And yet the explanation is not far to seek. Our services have always been expensive to work ; they are becom-

ing more expensive year by year. In America train-loads are mainly limited by the capacity of the engines; ours by the weight of goods or number of passengers that have had time to accumulate in the very short interval between one train and another. Let me illustrate: If a man is sailing from New York to Europe, he will choose his favorite line or his favorite boat, regardless of the time of day or the day of the week at which it starts. On the other hand, if the Manhattan Elevated were to try to run its trains only once in ten minutes in the slack hours of the day, the street-cars would rob it of the bulk of its passengers. Now, in England our business is all between places which in America would be regarded as close together. We call Manchester "the north of England," yet Manchester is only 4¼ hours from London. Consequently there must be trains between the two points at all hours of the day, to suit the convenience of passengers wanting to go at any time. Consequently, too, each train runs with very much less than a train-load of passengers. Then these trains must be run at high speeds; for, though a few minutes more or less are of little importance in a journey of hundreds of miles, a quarter of an hour out of four hours is a very considerable percentage. High speeds mean few stops; and few stops mean additional trains to serve the second-class stations. Then high speeds and frequent expresses for passengers mean high speeds and short trains for goods,—that is, half-loaded engines; for an engine loaded to its full capacity moves so slowly—occupies the line, that is, for so long a period—that it is impossible to find room for it.

But it would not be true to say that the goods are worked at high speed simply for the convenience of the railway management. On the contrary, the demand for speed in the case of merchandise traffic is fully abreast of that in the case of passengers. Broadly, it may be said that the English goods-service is based on the supposition that, between important towns at least, whatever is handed to the railway company at the forwarding station over night will be delivered to the consignee the first thing next morning. Now, a service such as this, in the nature of things, can never be a cheap one.

But our service is expensive in many ways beyond the cost of mere movement. Continental railways stop on the outskirts of the towns; American railways have, it is true, their depots in the heart of them; but the depot is almost as old as the town itself, and is built on land bought probably almost at agricultural value. In England alone do the railways come into the heart of ancient and

populous towns, occupying for their stations not merely land bought at building value, but land which was actually covered with buildings that had to be bought and pulled down to make room for them. I may be told, and no doubt truly, that terminal accommodation is costly in the great American cities. But the terminal cost of grain, say from Chicago to New York, spreads out pretty thin per mile when there are a thousand miles over which to spread it. President Roberts stated at a recent annual meeting of the Pennsylvania Company that the average cost per ton-mile on the line between Jersey City and Philadelphia was 1 cent, as against 4 mills on the rest of the system, and even on the New Jersey division of the Pennsylvania railroad I should imagine that the average length of haul over which to spread the cost of the terminal accommodation and services is a good deal more than our average of some twenty-five miles.

It must be remembered further that the costliness of the land on which our goods-stations are built operates indirectly also to increase the cost of service. Most of the London goods-stations, for instance, are built in two stories, and the goods-wagons are raised or lowered from one to the other by hydraulic lifts. Further it must be remembered that, in the case of the bulk of our merchandise traffic, the rates include the cost of collection from the consignor's place of business at one end and delivery to the consignee's place of business at the other. In fact, it may fairly be said that in many respects our goods rates should be compared, not with American freight rates at all, but with the rates in that country for "express." Let me give an instance: Happening lately to look in the rate-book at a small town in Yorkshire, I found that the rate for fifth-class—our highest class—traffic to a station five miles off was quoted as 15s. 5d. per ton,—in other words, 3s. 1d. per ton per mile. This sounds very terrible, but turn it another way round, and say that for the sum of 9d. the railway company fetches a case of hats or a bale of silk weighing 1 cwt. to the station, loads it into a truck, carries it five miles, unloads it, and delivers it in a cart to destination,—imagine all this, and this is what fifth-class traffic really means,—and the wonder will rather be whether the railway company is not out of pocket by the transaction. To sum up in a phrase: the difference between English and American railway service is that the American companies sell transportation wholesale at wholesale prices; the English companies transact a retail business and charge retail prices.

But it is not only to different methods of construction and transportation that the difference between the cost of English and American service is due. There can be no doubt that the newer civilization of America disregards the interest of the individual for the benefit of the mass in a way that startles our more conservative minds. I have ventured already to point out that the American farmer, who is knocked down and killed at a grade-crossing by a passing train, suffers that his fellow-citizens may have cheap railway service. I have indicated too how tender our Parliament is of the rights of the landowner whose property is condemned. The same general principle, I think, applies to the different views taken in the two countries in reference to questions of so-called preferential rates given to one district and refused to another. I must not go into abstruse comparisons between laws there and here. I am of course aware of the existence of the long- and short-haul clause in the Interstate Commerce Act. I know, too, that not a few attempts have been made in America, by legislatures and by railway commissions, to use exceptionally low rates, forced upon the railways by competition, as a measuring-rod for the adjustment of local non-competitive rates. But for all that it is true on the whole to say that American railways have been more free than ours to base their rates purely on commercial considerations, to adopt the only sound economic basis of a tariff,—that of charging what the traffic will bear. It seems to me that they have been able to do this because the American public was wise enough to regard mainly the interest of the consumer,—that is, the country as a whole,—while our public have been weak enough to listen to the expostulations of the individual producer fearing the loss of "the advantage of his geographical position," and to forget that his loss would be the consumer's gain. If permitted to generalize yet more widely, one might point out as a very curious fact, that in the United States, the most pronounced Protectionist country in the world as against foreign nations, internal intercourse is less restrained than anywhere else, while England, which is immovably on the side of free trade with foreign nations, has failed to see that the same logic which refuses to protect the English farmer by a duty on American wheat should compel the State to stand aside and leave English railways free to carry American imports regardless of their origin, at such rates as they find for themselves most commercially profitable.

There can be no question that the tendency of the law of undue

preference as interpreted by English courts has always been to heighten the average rate charged. It is true that the decision in any individual case always leaves to the railway the alternative of either levelling up or levelling down, but I know no instance in which the railway company has in fact adopted the latter alternative. Let it not be supposed, however, that the legal tribunals are out of harmony with public opinion. The action of the legislature has been consistently in the same direction. The passage of the Railway and Canal Traffic Act of 1888 was followed by the withdrawal of large numbers of special low rates which had till then existed. That act, among other things, provided for a codification of all the maximum powers of charge of all the companies in the kingdom. Since January 1, 1893, this codification has come into practical force. Symmetry and simplicity have unquestionably been attained thereby; but if the universal protests of traders' associations have any foundation in fact, the uniformity has been reached much more by raising exceptionally low charges than by reducing exceptionally high ones.

But I have pursued, perhaps, too far already questions which are rather commercial and economical than matters of practical railway working. In my next paper I shall hope to deal less with the abstract causes of the difference between the railways of the two countries, and more with the concrete examples of it.

FALLACIES AND FACTS AS TO IMMIGRATION.

By Colonel John B. Weber,

United States Commissioner of Immigration, Port of New York.

I HAD the pleasure recently of addressing an audience in Cooper Union, New York, upon the subject of Immigration, and the editor of THE ENGINEERING MAGAZINE was so favorably impressed with what I had to say that he has requested me to prepare a résumé of the address for publication in these pages. It gives me pleasure to comply, for I deem the subject one of first interest and importance to the wide circle of practical men of affairs who read a magazine of this character.

The migration of human beings from one country to another, although seeming to proceed so freely, must not be attributed to slight causes. Given the same conditions, or even approximately the same, the average man is content to live and die about where he was born. The desire to enjoy a larger degree and a fuller measure of political equality in years gone by stimulated many Europeans to seek new homes in the United States. But this is not now much of a factor, for, with the exception of Russia, the thrones of Europe are so hedged in by nineteenth-century limitations as to be comparatively powerless for oppression. The great lodestone which has attracted by far the greater number of immigrants to our shores is the superiority of the conditions which prevail here over those existing abroad. You may attribute immigration to the advertising of land companies, to the greed of steamship agents eager to sell tickets, or to a desire to evade military service, and you will embrace after all but a small portion of the great volume tending to our shores. But when John, who has established himself here, writes to his brother Jacob, who remains in the fatherland, to come, because of the better opportunities to be found, the information springs from one who has tried the conditions in both countries and is sent to one who is influenced by the statement, not because of its bright colors, but because of its source.

We have received immigrants, as a rule, from the laboring and agricultural classes of Europe. The inhabitants of cities do not emigrate in considerable numbers, with the exception of those who belong to the ranks of laborers. A majority of the arriving immi-

grants is still destined for the western agricultural States, although a considerable portion remains in the large cities, especially in the east, on account of the tendency of the rural population to flock to the cities, which is observable everywhere in Europe, as well as here. To me the reasons for this drift from the country are plain,—namely, the easier conditions of life in the cities, a better opportunity for acquiring wealth, the superior educational facilities, and the more numerous attractions. The greater the improvement in the conditions of workingmen in cities, however brought about, the greater will be the exodus from country to city, the greater the congestion, and the keener the competition in the higher grades of labor in cities. When this becomes so extensive as to raise farm wages correspondingly, through depletion of the rural population, the movement will be checked, and the flow will turn the other way.

I presume that no one will dispute the advantages to our country of immigration in the past. We owe to the hewers of wood and the drawers of water,—to the hard-fisted toilers from abroad,—the building of our railroads, the digging of our canals, the springing up of cities, the creation of new States, and some acknowledgment for their share in contending for the supremacy of the Union in the country's great crisis. Since the earlier days of the republic the manual labor involved in these industrial achievements has been hired by the native American, whose superior intelligence, ability to command, shrewdness, and ingenuity have easily made him the leader for foreigners to follow.

But the question now before the country is what about the present and the future of the immigration problem. Of late years there has been an increasing stream from southern Europe of a class more illiterate than the more northerly element which formerly filled the ranks of migration in this direction. It is contended that this vast aggregation of ignorance is detrimental to the welfare of the United States. If this is true, we should stop it. Whether it is detrimental or not, we should at least diagnose the case carefully before proceeding to heroic treatment, for immigration is a growth, not an explosion, and the volume is so strong and the momentum so great that the air-brakes cannot be suddenly applied without a shock that will disturb existing conditions throughout the land.

It is urged by some that the incoming of foreigners brings about an unhealthy competition in the labor market and reduces wages; but where is the evidence that this is generally so? The tendency of wages here for thirty years past has been steadily upward, with

hardly a check. Others claim that the foreigners contribute an abnormal share of inmates to our poor-houses and prisons. This is probably true, but it is because the foreigner belongs to the poorer half of the community. The pathways leading to crime too often branch off from the avenues of necessity. Still others complain that the ignorant element does our voting, controls legislation, and in the cities administers public affairs generally. This, if true, should be charged to the naturalization practice and not to immigration. But all of the ignorant vote is not on one side of the political line, and to the extent that it is divided one side counterbalances the other. The failure to neutralize it more nearly is due in part, at least, to the indifference of native-born citizens to the performance of their political duties.

There are still others who say that our population is becoming too dense, and that immigration should be stopped before we are actually in need of elbow-room. It has been estimated, however, by accepted authorities that we can accommodate seven times our present numbers without equaling Europe in density of population. The single State of Texas could have taken the entire inflow of the past ten years, with advantage to her interests, and still have had room to spare. Europe, in truth, does not suffer so much from over-population as over-taxation to support royalty and immense standing armies and navies, making the burden so heavy as almost to obliterate the great middle class, which is the strength as it is the pride and glory of this land.

Let us now consider briefly the various plans for adding to the existing restriction of immigration, now revolving in the public mind, and point out their probable effects and seeming defects. Congress has the power to stop immigration altogether, or to prescribe an educational test or a money qualification, or to exclude nationalities,—as has been done in the case of the Chinese,—or to prescribe any other restrictions, wise or foolish. If there had been in force from February 1 to November 1, 1892, an educational test, —namely, the test of reading and writing,—there would have been shut out at the port of New York, of those above the age of sixteen years, 57,000 out of 275,000 arrivals. If we had had the money qualification from January 1 to November 1, 1892, for persons over twenty years,—say $100, which is the amount most commonly suggested,—we would have shut out 194,000 out of 202,000.

I am not now advocating either of these plans, but simply desire to show their effect, believing it always to be wise, before en-

acting a law, to consider what will be the result. Take, for instance, the Scandinavians, who present the smallest percentage of illiterates. Out of 42,000 arrivals during the period mentioned they showed but 289 who could not read and write. In this respect they made a better showing than would the population of any State in our Union. But they averaged only about $23 per capita for the same period. Of the 30,000 Scandinavians over twenty years of age less than 1300 would have been admitted under the $100 money qualification. Had this policy been adopted a few years ago, where now would be our Minnesota, our Dakotas, and portions of other States where, while the preponderance of Scandinavians is not so marked, their numbers are yet important? The present governor of Minnesota, Knute Nelson, would most likely still be plodding along in Norway had the money qualification been in force when he landed at Castle Garden. He is a strong character of marked abilities, who, although a foreigner, fought under the nation's flag for the preservation of the Union and the protection of the interests of all, native and foreign. In every walk of life, in the sciences and arts, in commerce and finance, in literature and the professions, we find foreigners who have lifted high the standard of progress in this country. Can any one advance a good reason why these people should not have come in?

Another plan which has been proposed, and which to the superficial observer seems to be the panacea for all our immigration evils, is that of inspection abroad by American consuls. This plan, I contend, would be the weakest in good results, the strongest in disadvantages, the most expensive in its enforcement, and the most deceptive and barren in its yield. It is a most cumbersome and complicated machinery, whose chief result would be to furnish the very people we do not want, and keep back those who are desirable. Almost the same result could be obtained by passing a law saying that no one shall come in who is physically able to care for himself, and that only those shall come who have just left the cradle or are nearing the grave. I don't believe in cross-eyed politics or cross-eyed policies. I don't believe in squinting at cholera and striking at immigration. I don't believe in indirect means to carry out that which we have the power to do directly. I don't believe in chanting our praises for furnishing an asylum for the oppressed and laying for these people with a shotgun at the border. I don't believe in exercising a power that has not the moral force and conscience of the community behind it.

Consular certification must be made either in the consular districts where the emigrant lives, or at the seaport where he embarks. At neither place has the consul personal acquaintance with the subject. He must obtain his information from the local authorities over whom we have no jurisdiction, and who may be expected to facilitate the emigration of the bad and hinder that of the good. I may illustrate by mentioning that the Italians must all have passports before they can legally leave their country, and no one against whom a criminal conviction has been recorded is supposed to receive such a document. Yet I recall a number whom I returned,—one in particular who had served ten years in prison, but who had a clean bill of moral health in the shape of a passport.

The results of the cessation of immigration are too far-reaching to be disposed of here, but I desire to call attention to one or two features which are certain to develop. First, we have been for years feeling the lack of sufficient domestic help, and where the servant girl of the future will come from, if we close the gates to immigration, I don't know. It may be said that we can make exception in the case of women, but women will not come unless their brothers and fathers, husbands and lovers come too. Where are the American girls who are ready to go into the kitchen? Indeed, it is all that we can do to keep the foreign girls in the kitchen after Americanizing influences have caused them to discard the kerchief tied around their heads upon landing, and don the high hat with feathers and birds instead. Then who will do the rough work constantly necessary in the development of our but partially touched natural resources? Will it be those who are already here, and who have been elevated above that grade of work? Hardly, for that means retrogression, and I do not welcome the day when the toilers of this country are obliged to take a backward step either in compensation or in position. Remember, too, that the labor that these raw hands perform makes the demand for work requiring more skilful touch. Coal and ore must still be mined, forests leveled, and fields plowed, and hundreds of what may be called coarser vocations must be filled by men who do not wear silk hats and dress coats. There must be privates in the industrial army, as well as brigadiers.

The natural increase in population will not supply the waste of time and the decay of brawn and muscle. Large families are no longer the fashion in America. Take the figures of population in the last census, deduct the arriving immigrants for ten years past, and we would show but a small growth during that period.

"We don't believe in unrestricted immigration," say some who have given very little study to the subject. Nor do I. Such people talk as though there were now no restrictions. There are on our statute-books laws excluding the insane, idiots, persons suffering from dangerous diseases, paupers, persons likely to become paupers, convicts, polygamists, and contract-laborers. Under these laws the immigration commissioners of New York State, during the five years preceding the control of the business by the Federal authorities, barred and returned to Europe 1977 people. From the beginning of Federal control, namely, April 19, 1890, to November 1, 1892,—about two years and seven months,—3051 persons were barred and returned. Besides, there were returned under the year clause (which I will refer to later) from the time that the law became operative, April 1, 1891, to November 1, 1892, 937 persons. This certainly shows some restriction.

"But we are receiving the scum of Europe, and paupers and criminals are dumped in wholesale fashion upon our shores," is said by some who have skimmed the surface, or by those whose real desire is to exclude all immigrants because it just now seems to be popular, but who seemingly have not the courage to avow their desires. There has been a great improvement in the sifting process at the threshold of the country. The practice of the authorities here, which is founded not upon mandatory law, but upon regulations, has been to take care of those who fall into distress within twelve months of their landing at the expense of the immigration fund, instead of sending them to the city hospitals at the expense of our tax-payers. The year 1889 showed an average daily attendance of 266 such immigrants. By 1892 the daily average had declined to 81 and a fraction. As to the assertion that Great Britain is dumping her paupers and criminals upon our shores, there may be isolated cases of this kind, but that there is a wholesale organized movement I do not believe. The facts on record in this connection are mainly ancient history.

The plan that I would suggest is laid down in a report made by Dr. Kempster and myself, from which I have seen no reason to deviate, except to add a clause vesting in the president of the United States the power to suspend immigration temporarily in the case of threatened pestilence, and possibly an educational qualification. The report was written before the outbreak of the typhus and cholera last year, and before illiteracy statistics were kept at the Immigration Bureau. I would hold the sub-agents of

steamship companies, many thousands of whom are scattered over Europe, responsible for the sale of a ticket to a prohibited person, reaching him not directly by our law, for that is impossible, but striking his pocket through the steamship agencies or companies in this country, compelling him to pay the return passage of a defective immigrant and levying a fine in each instance if necessary; in other words, imposing a penalty which in a single case would wipe out the commission received in a great many. The sub-agent in most cases knows the applicant personally, lives in the same village with him, is familiar with his family history, and knows his conduct and his mental and physical defects better than any one who comes in contact with him after he leaves his home.

I would continue a rigid inspection here, and besides hold every alien immigrant after landing subject to compulsory deportation at the discretion of our courts whenever he developed into pauperism or criminality, and until he had assumed the burdens and acquired the privileges of citizenship. He would be regarded, in fact, as passing through the Immigration Bureau until he became a citizen. Every country in Europe except Great Britain deports alien paupers and criminals to their homes, and there is no sentiment or good reason which we would violate by adopting the same plan. We are now authorized to return to Europe within twelve months after landing a person who has arrived in violation of the immigration laws, or who becomes a public charge from causes existing prior to landing, and under this authority we returned more than 500 persons last year who could not have been detected by any process of inspection here or abroad, nearly all of whom would have become a permanent burden upon the public. Wipe out this year limit, extend it to cover the period of citizenship, and eliminate the requirement that we must show that the cause existed prior to landing so as to take in one who becomes a pauper or a criminal here, and we solve the problem of how to get rid of the undesirable element coming to us from abroad. Then guard better the avenues of citizenship, and a great many of the immigration evils will disappear.

In the enforcement of the contract-labor law it is exceedingly difficult to reach every case. The original intent of the law has been realized,—namely, the stopping of the wholesale importation of gangs of contract laborers. Individual violations of the law will occur doubtless as long as cases of smuggling and evasions of the customs laws occur. A practical remedy for these isolated cases is

not easy to provide, but I believe that much could be gained if it were made easier to inflict the penalty upon the contracting party living here, instead of having that punishment fall as now upon practically innocent men, ignorant of our laws, who are returned because of their unintentional violation of them.

There is one other side to the immigration question upon which I desire to touch, and that is charged as being the sentimental side. I believe in sentiment in a government as well as in the home. Sentiment is part of the power that moves the world. We are all immigrants, differing only in the sailing dates of our ancestors. A few came over with the *Mayflower*, but the great mass of them came within the past fifty years, during which time the progress of the nation has been so rapid and so vast that it staggers arithmetic to compute and impoverishes language to describe it. And because I believe the marvelous achievement of which we boast to be so largely due to the incoming of immigrants drawn from the bone and sinew of all Europe,—for by reason of this we come in contact with new ideas, adopting the best and rejecting the worst,—I am not in favor of shutting off the vigorous, health-giving current because there may be a small rivulet of impurities trickling into it. Stop the impurity abroad and here as far as possible, and turn back the rest upon discovery after landing. I am not in favor of any plan which reaches beyond the exclusion of the physically and mentally weak, the vicious, the diseased, the dangerously ignorant, or those whose labor is contracted for on the other side to the detriment of the better-paid and higher-grade labor of this country.

At the entrance of our harbor, on a great granite pedestal, stands a statue, a figure of our national goddess, christened "Liberty Enlightening the World." Borne aloft in outstretched hand, burns a torch, which up to this time has cast no ray but that of welcome. Wherever the spark of liberty has kindled hope in human breast, wherever hope has crystallized into effort, that torch has been the beacon-light for persecuted humanity, the cloud by day and the pillar of fire by night. If it means this no longer, let us correct its reading as speedily as possible. Change the character of that symbolic figure; tear from its forehead its beautiful crown; let it be considered a grim sentinel forbidding approach; and let the light which dances over the waters of our beautiful bay mark a dead-line across which an alien immigrant will pass only at his peril.

THE DEARNESS OF "CHEAP" LABOR.

FROM AN ENGLISH POINT OF VIEW.

By David F. Schloss.

THE general increase in the remuneration of labor, which has taken place during the last three years throughout the length and breadth of the United Kingdom, has been witnessed by social reformers of every class with profound satisfaction. At the same time the fact that British trade, upon the prosperity of which the welfare of all sections of the community alike depends, is at the present moment severely harassed by foreign competition, is undeniable; and since many of our rivals have at their command labor remunerated upon a much lower scale than that prevalent in this country, it is not surprising that it should be asked: What chance can we hope to possess of holding our own in the contest for commercial supremacy if we go on steadily augmenting our wages-bill, while our competitors enjoy the advantage of cheap labor? To this question, however, it is proper to oppose another: Is it an advantage to a nation that its workers are ill paid? in other words, is low-paid labor really cheap?

The fallacy of the supposition that high wages necessarily involve a high labor-cost was pointed out more than a century ago by Adam Smith, who declared that "the wages of labor are the encouragement of industry, which, like every other human quality, improves in proportion to the encouragement it receives." Later on Senior showed that, although the French manufacturers paid much lower wages than the English, yet the cost of production was decidedly higher in France than in England. Still more copious proofs of the dearness of cheap labor were adduced by Lord Brassey, whose father, in carrying on extensive works in all parts of the world, had employed in turn many different kinds of labor remunerated upon very various scales, from the highest to the lowest. But Lord Brassey's "Work and Wages" was published twenty years ago; and since, in a question of so much importance as this, fresh facts are especially valuable, it may not be amiss to apply to its consideration the test of more recent experience.

Beginning with those industries in which the labor employed is of the coarsest kind, muscular exertion unaided by machinery being

the main factor in production, the fact that in coal-mining high earnings, as a rule, go hand in hand with low cost of production appears very plainly from a table given in a valuable work lately published by the distinguished American expert, Mr. J. Schoenhof*:

State.	Yearly Earnings.		Wages per Ton.	
	1880.	1890.	1880.	1890.
Tennessee	$332	$392	.68	.82
Kentucky	261	334	.73	.70
West Virginia	295	391	.72	.60
Ohio	320	352	.86	.69
Illinois	382	357	.99	.69

If, again, availing ourselves of figures placed before the Labor Commission by Mr. J. S. Jeans, Secretary of the British Iron Trade Association, we compare the conditions under which coal is mined in the United States and in Belgium respectively, we shall find that, although the average annual earnings of all persons employed are in America more than double those received in Belgium, yet the labor-cost of each ton raised is lower in the American than in the Belgian mines.

Proceeding to examine the facts in relation to the manufacture of pig-iron, we learn from a book on "The Principles of the Manufacture of Iron and Steel," written by the great ironmaster, Sir Lowthian Bell, that the expenditure in wages incurred in producing one ton of pig-iron is seldom smaller in Germany than in England, though the Cleveland ironmasters pay wages from 35 to 40 per cent. higher than the German employers.† Still stronger proof of the superior efficiency of well-paid labor is afforded by the figures, founded on the accounts of an American blast-furnace, which are given in Mr. Edward Atkinson's "Distribution of Products," and which prove that, as between the two periods, 1860–64 and 1875–79, the cost in wages for each ton smelted exhibited a decrease of 14 per cent., while the annual earnings of each man employed had increased 37.68 per cent., and his output had augmented at the rate of no less than 55.82 per cent. Turning back to the pages of Mr.

* *The Economy of High Wages.* New York and London: Putnam. 1892.

† In 1878 (six years before the publication of Sir L. Bell's book) a German commission reported that the cost in wages of the daily output of a German blast-furnace was 145.77 marks, while the labor-cost of the same quantity of pig-iron in the Cleveland works was only 115.77 marks.

Schoenhof's book, we find that this very careful author, basing his statement on actual working accounts, informs us that the labor-cost of making a ton of pig-iron is less by 1s. 9½d. in Pittsburgh than at Middlesborough, and this though the English workman receives wages lower by about 40 per cent. than his American compeer. Nor is the superiority of "dear" labor less patent when we compare with each other the different parts of the American republic. For, in a recent report of the United States Commissioner of Labor it is stated that, while in the Southern States, where a man's earnings are upon a relatively low scale, ranging from 10.5 to 12.1 cents per hour, fourteen out of a total of twenty-one establishments show an output of less than .08 of a ton per man per hour, and of the remaining seven, five have an output of under .10, in the Northern districts, in which labor receives a higher remuneration out of fifty-five establishments, paying wages of from 11.1 cents to 18.7 cents per hour, no less than forty-three can show an output of .08 of a ton per man per hour or more, twenty-six of these producing at the rate of .10 of a ton per man per hour and upwards.

So far we have been dealing with industries in which the labor of the workman receives no assistance, or only a minimum of assistance, from machinery. In most forms of modern industry the abundant use of machinery, especially of machinery driven by motive power, plays an important part; and in this connection it is of importance to remark that, while the judicious adoption of mechanical improvements constitutes a very potent means of keeping down the cost of production, nothing so strongly tends to promote the introduction of perfected machinery as the prevalence of high wages. It might, indeed, appear natural to suppose that the desire of manufacturers to increase their profits would, of itself, suffice to induce them to diminish the cost of production by introducing machinery wherever possible. But, as a matter of fact, so long as an employer can get his labor "cheap," he does not bother his head about labor-saving appliances. Thus, it was only after the Gas Light and Coke Company had been obliged to concede the demand made by their men for the introduction of an eight-hours working-day, and had thereby incurred an extra expenditure in wages of £70,000 a year, that these employers thought of adopting machinery for the purpose of drawing and charging their retorts; nor, until their coal-porters insisted on having their wages raised very considerably, did the Company begin to make use of mechanical appliances, which now enable them to get the work done at a rate

lower even than what it had cost them before this demand for increased wages was made. There can be no question that the high remuneration of labor affords a most valuable stimulus to the energy and the inventiveness of employers; while obsolete and wasteful methods of production will be observed to prevail where low wages are the rule.

In many English industries the pressure of our relatively high wage-scale has been sufficient to secure the adoption of methods of production greatly superior, at any rate, to those prevalent in the Continental workshops. Yet even in these industries the still higher rates of wages current in the United States have led to the introduction of appliances in a notable degree more perfect than those used in England. Thus, in the manufacture of rails, Mr. Schoenhof tells us that much of the work, which at Middlesborough and Darlington is done by simple manual labor, is in the United States performed by automatic appliances, the consequence being that the American employer is able to give his men two-thirds more pay than his English rival, and is nevertheless in a position to turn out his rails at an expense for labor less by over 17 per cent. than the labor-cost in this country. But it is when we come to those English industries in which wages are but little above starvation point that the stagnation prevalent wherever manufacturers enjoy "the advantage of cheap labor" is most plainly visible. Take, for example, the nail-making trade carried on in the Midlands, a trade the condition of which has long been a disgrace to the fair name of English industry. In 1713 (as we learn from Mr. W. A. S. Hewins's "English Trade and Finance") the nailers worked from 4 o'clock on Monday morning until late on Saturday night for 3s. a week. The evidence taken by the Sweating System Committee in 1889 showed that a man and his wife can only earn between them from 10s. to 17s. in a busy week, and average much less. Much of the work is done in wretched hovels, often under most insanitary conditions; and many of the women injure themselves in a grave manner by the use of the heavy "oliver," employed in cutting the cold iron. But in America, as Mr. Schoenhof proves, the manufacturers, availing themselves of the best methods and the most improved machinery, are able to turn out nails at one-half the labor-cost incurred in England, and that although the American workman receives wages fully ten times as high as those of the Dudley nail-makers.

The instance just cited may be taken as an extreme case of the

pernicious effect of low wages in checking the legitimate economic evolution of a manufacturing industry. But, in truth, the conditions under which our nail trade is carried on, with its retention of wasteful and vicious methods of production, with its domestic workshops, with that irregularity of employment which is the invariable accompaniment of the domestic, as distinguished from the factory system, with its multiplication of little masters and of middlemen ("foggers") buying the output of the scattered forges to sell it to the "manufacturer,"—all these conditions are present in each and every one of those numerous "sweated" industries, the evils prevalent in which have, ever since Mr. Burnett, the labor correspondent of the Board of Trade, made his famous report on the sweating system in 1887, received so large a share of public attention. The horrors of "the sweating system" in the clothing trades were so fully exposed before the Lords' Committee that it were needless to describe them here. But what it may be useful to point out with all possible distinctness is that the real reason why these horrors exist is simply that the employers in these sweated trades have, in the absence of that invaluable stimulus which the pressure of high wages can alone adequately supply, resolutely set their faces against the adoption of improved methods of manufacture. If the manufacturers, who ask us to believe that the retention of "the sweating system" is an economic necessity, would only muster up sufficient energy to erect proper factories provided with improved machinery run by steam-power, then, with suitable organization, they would find it perfectly feasible to sell their goods as cheap as ever, and yet to pay decent wages to their workpeople. This is no wild hypothesis: the thing is actually done. In the metropolis the wholesale clothing firms, having at their command a boundless supply of "cheap" labor, have (with very few exceptions) steadfastly declined to avail themselves of modern appliances, preferring to send their work out to be done in the slum work-rooms of East London under the worst possible industrial conditions. But in the provinces (at Leeds, for example) there are magnificent tailoring factories in which the pay and the conditions of labor are incomparably superior to those prevalent in the metropolis, and which nevertheless find themselves easily able to keep pace with the "sweating-dens" in the race for cheapness of production. What is true to-day of the tailoring trade was, until a short time back, no less true of the boot trade, as carried on in that pet paradise of the purchasers of cheap and nasty labor, the East

end of London. Prior to the strike against "the sweating system" (in April, 1890), the London manufacturers used to send their boots out to be "finished" to "sweating-masters," who got the work done in noisome garrets and cellars by men working eighteen hours a day at a wage of about 3d. per hour. It was in vain to remind the London manufacturers that in the American factories, as had been conclusively established by Mr. Schoenhof's Consular Report of August, 1888, the very same processes were being performed by men in receipt of high wages, but assisted by the most efficient power-driven machinery, actually at a lower cost than in the Brick Lane "sweating-dens." So long as these employers were able to get their labor "cheap," so long did they stick to their obsolete methods of production. Now, entirely as a result of the pressure applied and maintained by the operatives, who have insisted that low cost of production shall no longer be secured by means of the oppression of the workers, the American machines have been freely introduced both in London and in the provinces, and no one to-day could venture to assert that "cheap" sweated labor is essential to enable English boot-manufacturers to compete successfully with their foreign rivals.

No better proof of the direct influence which high wages exercise upon the productivity of machinery could be given than that which is afforded by the history of our great textile trades. If we go back to the first years of the century, we shall find the gradual rise in wages accompanied by a steady increase in the efficiency of the operatives. Thus, while in 1804 an operative spinning fine cotton ("200's") turned out no more than nine pounds of yarn in a week of seventy-four to eighty hours, earning, after paying his assistants ("piecers"), a net wage of 36s. 6d., in 1833 the output of a man employed (on similar work) for only sixty-nine hours in the week was no less than nineteen pounds, and his net wage was 42s. 9d. It was shown before the Committee on Artisans and Machinery which sat in 1824 and 1825 that, while the earnings of English cotton-spinners were double those paid to French operatives, the Englishman got twice as much off a given number of spindles as the Frenchman. In 1836 Ure, in his work on "The Cotton Manufacture," said that the daily output of 800 spindles when spinning "40's" was sixty-six pounds in England, but only forty-eight in France. But the Lancashire of 1892 is even further in advance of the Lancashire of 1836 than the Lancashire of 1836 was ahead of the France of that date. For, if we compare the figures given by Ure

with those contained in the excellent study of the cotton trade which has recently proceeded from the pen of that competent economist, Dr. von Schulze-Gaevernitz, we shall find that the work which in 1836 it took 508 of our operatives (spinners and piecers) to perform is now done by 97 only. To give an accurate idea of the superiority of the British cotton-spinner of to-day over his foreign compeers would scarcely be possible without entering too much into the technical details of the manufacture. But a few salient points may usefully be mentioned. While (as Dr. von Schulze-Gaevernitz states) in many of the German mills it takes five "hands" to tend one pair of self-actor mules with only 1300 spindles, and while even in some of the best German factories the same number of operatives is required to tend 2000 spindles, in Lancashire (although we run our machinery faster than the Germans) a pair of mules with 2000 spindles is worked by one spinner with only two assistants. Another matter well worthy of notice is the fact that, while in the smaller German mills there is one overlooker to 3000 or 4000 spindles, and in the best German factories one overlooker to 10,000—20,000 spindles, we in England require only one overlooker for from 60,000 to 80,000 spindles. Now let us turn to the comparison of the work of English and foreign operatives given by Dr. von Schulze-Gaevernitz (his figures relating to the manufacture of "36's twist"):

	No. of spindles on each pair of mules.	No. of operatives to each pair of mules.		No. of hours worked per week.	No. of pounds of yarn spun by each pair of mules per week.	Labor-cost per lb. in pfennigs.	Wages of operatives per week in marks.	
		Spinner.	Assistants				Spinners.	Assistants.
Southern Germany.	1,472	1	3	65	1,095.5	4	21	7.70
Switzerland.....	1,200	1	2	65	850	3.9	18	7.50
Saxony.....	1 704	1	3	65	1,550	3.35	21	8-13
	2,000	1	3	64	1,800	3.2	22	9-13
Oldham.....	2,376	1	2	55	2,182	3.25	38	17.75
	2,688	1	3	55	2,723.6	2.88	40.15	12.9

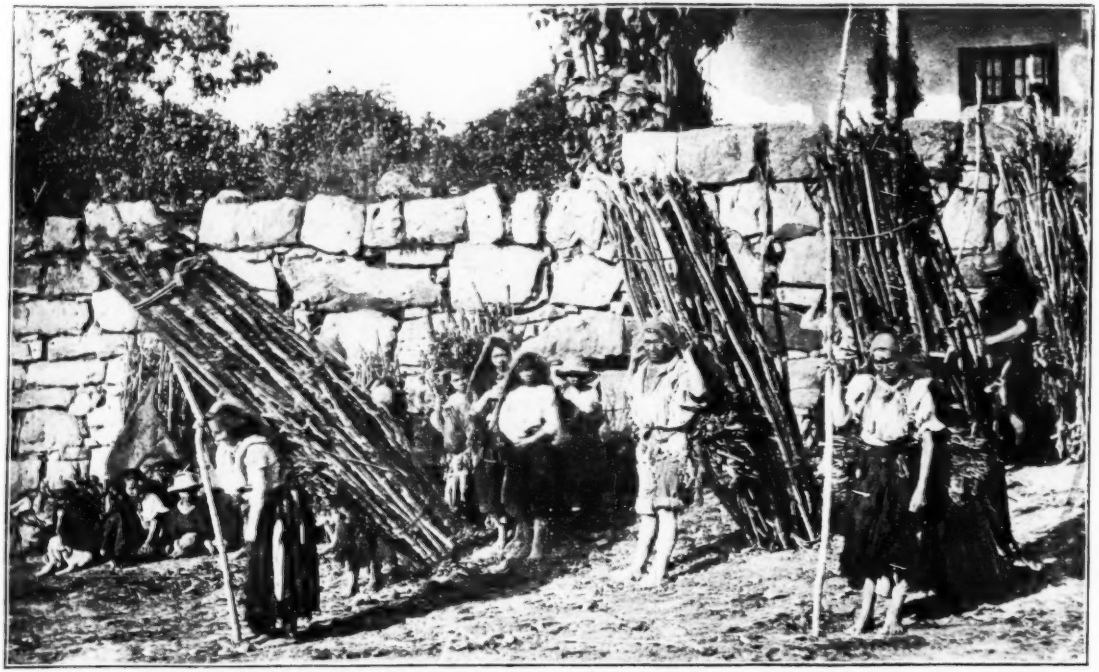
If we contrast the first with the last of these rows of figures, and remark that, while the rate of pay (per hour) in the German mill is

lower in the case of spinners by over 120, and in the case of their assistants by about 100 per cent. than that received by the Oldham operatives, the labor-cost is nearly 40 per cent. higher in Germany than in Lancashire, we shall not fail to see how great is the disadvantage to our foreign rivals of that "cheap" labor which is, in truth, so extravagantly dear. What is true of cotton-spinning is no less true of cotton-weaving. The well-fed English weaver can without difficulty look after four looms, and can with the aid of a juvenile assistant ("tenter") manage as many as six. But, as Dr. von Schulze-Gaevernitz tells us, notwithstanding that the Continental manufacturers run their looms from 20 to 30 per cent. slower than ours are worked, in Mulhouse and in Switzerland each weaver can only tend three. The effect of the superiority of the English operatives upon the cost of production is shown by the fact that, although the rate of remuneration of our English weavers is about 100 per cent. higher than that received by the Swiss and German "hands," yet we are able to turn out cotton cloth at a labor-cost distinctly lower than that in Switzerland and Germany.

It is, of course, impracticable within the limits of this paper to deal fully with the whole of the textile industries. But let us take just a glance at the facts in relation to the woolen trade. It is well known that the wages paid to the operatives in our woolen industry are, to a marked extent, lower than those received by the "hands" employed in our cotton mills. According to the evidence given before the Labor Commission by a Bradford woolen-manufacturer, an adult spinner (at Bradford the spinning is done by women) earns from 7s. 6d. to 8s. 6d. a week, or if specially skilful from 10s. to 11s. 6d.; while women engaged in weaving are said, by one Bradford employer, to be able to earn 16s. 8d. in a good week, and, by another, to average 12s. 7¾d. a week throughout the year, a representative of the trade union assuring the Commission that their average earnings from year to year are only about 9s. a week. The warp-dressers in the woolen trade (mostly males) are shown to earn, if fully employed, 25s. to 28s. a week. Contrasting with these figures the earnings in the cotton trade we find that a first-rate cotton-weaver, whether female or male, can earn from 28s. to 30s. in a week, the earnings of a "hand" of average competence being 20s. a week, while the weekly earnings of cotton-spinners average 35s., and in some cases much exceed this amount. Now, the point of interest for us is that, while, on the one hand, this country is at the head of the world so far as the manufacture

of cotton goods is concerned, and sends its cotton yarns and cloths into all parts of the globe, on the other hand, in respect to woolen goods, such as are made at Bradford, we are totally unable to face foreign competition in the outside markets, the trade being carried on upon a relatively minute scale for the home market only. It is true that the splendid specialties of the Huddersfield manufacturers go all over the world, and nowhere meet their superior. But, then, the wages paid at Huddersfield are much higher than those paid in the other woolen-manufacturing districts.

Enough has been said fully to justify the assertion that, whatever be the difficulties with which our manufacturers have to contend, the comparatively low rate of wages obtaining in other countries cannot with propriety be reckoned among the obstacles to the success of English enterprise. On the contrary, the higher remuneration which our work-people receive, accompanied, as the higher remuneration of labor invariably is, at once by the superior proficiency of the operatives and by the superior efficiency of the methods of production, creates for English, as compared with foreign industry, advantages of the most precious character. It is scarcely too much to say that the most serious danger which British trade has at this moment to encounter arises from the improvement which is taking place on all sides in the position of the workpeople in rival countries. In Germany wages are every day higher; and with the increase in its remuneration the productivity of German labor is by slow but steady steps concurrently advancing. Even the wide gulf which separates the English from the Indian cotton-spinner is being rapidly narrowed. Within the last few years the remuneration of the Indian operative has risen from 30 to 40 per cent., while his industrial efficiency has nearly doubled. Under these circumstances it must be clear that the true line of deliverance for our English industries, hard-pressed as these unquestionably are by foreign competition, is to be found in the augmentation rather than in the diminution of the wages of English labor. Of all conceivable ways of combatting foreign competition, the lowering of the English wage-standard would be the very worst. Among economic axioms there is none which deserves a greater measure of respect than the profound truth that "the laborer is worthy of his hire." The belief in the "cheapness" of ill-paid labor is the most dangerous of all delusions.—*The Fortnightly Review.*



THE WOOD-CARRIERS—INDIANS OF THE BOGOTA PLAINS.

[Types of the people through whose country it is proposed to construct the Pan-American railway.]

WOULD THE PAN-AMERICAN ROAD PAY?

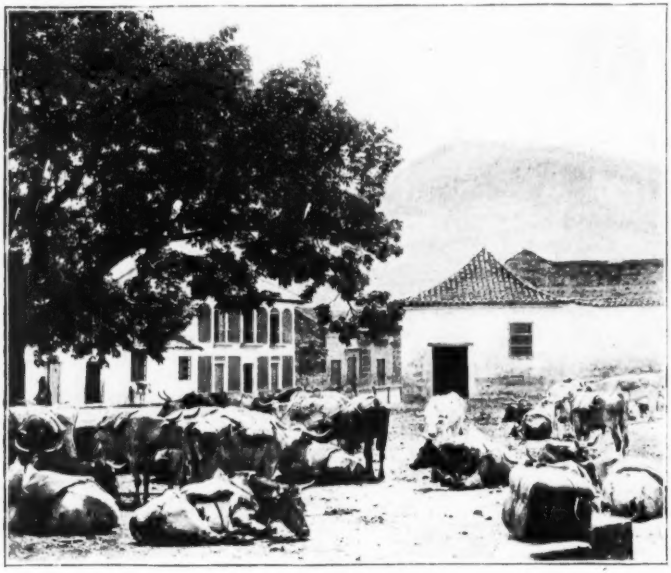
By Charles P. Yeatman, M. Am. Soc. C. E.

IN view of the impetus given to the idea of building a railroad to connect North and South America, by the recent Pan-American Congress at Washington and the subsequent surveys by the International Railway Commission, I feel justified in saying something on a subject which has been treated more sentimentally than practically. It may not be out of place to add that the writer is a civil engineer of more than twenty years' experience, most of which has been in railroad surveys and construction, including nine years in South America, almost in the pathway of the proposed line.

In considering this enterprise from a practical standpoint the first problem is not "Can it be built?" but "Will it pay?" An inspection of the map of North and South America will make it appear doubtful that it will ever pay as a through freight and passenger route, for at its best it will compete for 1600 miles with a route which has been built since the creation, and has not had one cent spent on it for repairs. Over it a ton of freight from South America comes to-

DONKEY LOADED WITH EARTH.

[Now considered a satisfactory means of transportation by the natives.]



A PACK-TRAIN OF BULLOCKS, JUST UNLOADED.
[Transportation means now suited to native needs.]

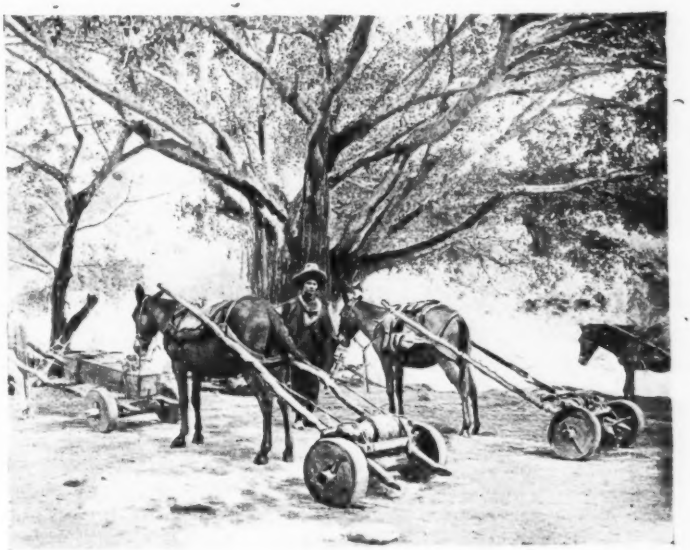
day at the rate of less than a half-cent per mile or about half the average railroad rate. These may be called monopoly prices, for competition thus far has been out of the question.

A writer in *The Forum* for March, 1892, in treating of this subject, assumes that Carthagena, in the northwestern corner of South America, is the natural shipping port of that country, and compares the distances from it to various points in the United States by the ocean route and by rail via the proposed Pan-American road. In round numbers the distance from Carthagena to New York is 2100 geographical miles by ocean, and 4000 by land. The writer in *The Forum* claims, however, that the difference in distance by the two routes becomes less as we leave the Atlantic coast, making the point of equal distance at Kansas City, any point west of that showing a comparison in favor of the land route.

This comparison is made under the strange assumption that all the ocean traffic must pass through New York or Newport News. The fact is that much of it, to-day, goes to New Orleans, through the Caribbean sea and Gulf of Mexico; and by that path the ocean

line to Kansas City, from Carthagena, is 2400 miles against 3100 via the Isthmus and Mexico. Hence, to reach Kansas City, the land line must compete in cheapness with ocean traffic for 1600 miles, and be handicapped by a loss in distance of 700 miles. On nearing San Francisco the distances become nearly equal, but the traffic would then be from the South Pacific port of Buenaventura, and the competition would be side by side with ocean traffic for 3500 miles; the land service competing with a line of steamers which carries passengers from San Francisco to New York, via Panama, for $125, or two cents per mile,—with one month's board and lodging included.

As the only part of the United States which would be as near to South America by rail as by a sea route is the Rocky-Mountain region, and as that is in no urgent need of rail connection with the tropics, we may say that as a means of saving distance the Pan-American railroad would be a failure. As a cheaper line for traffic it would hardly be a success. In saving time it might compete in the West for the carriage of passengers, mail, and express.



MODE OF HAULING HEAVY LOADS OVER THE ANDES.

[Pieces of the Bogota Mint en route.]

At present the trade of the United States with South America is made at the economical rate of ten miles per hour, but if necessary the speed could be increased to that of the transatlantic steamers, twenty-two-and one-half miles per hour, and at least 1600 miles of the railway would do well to average that rate of speed with its fastest trains. The most southerly point with which we have a rail connection is Jojutla, 183 miles south of the city of Mexico. From this point to Carthagena, via the Isthmus, the distance is

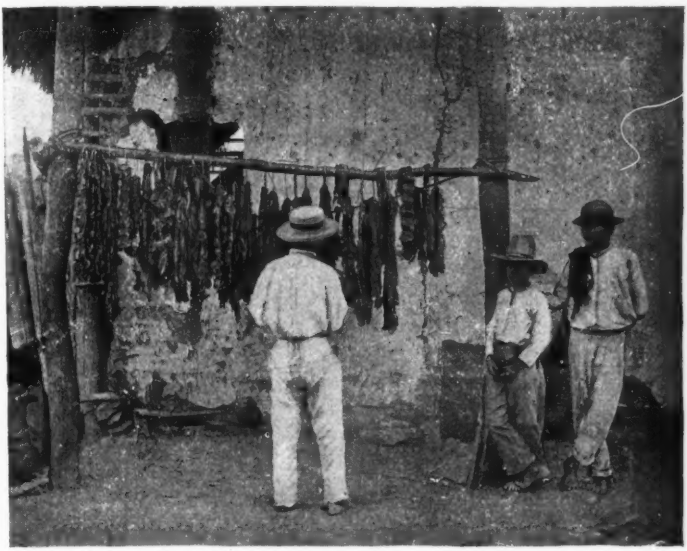
MAIN STREET OF PUERTO BERRIO, COLOMBIA.

1600 miles, through a sparsely-settled country, with a few short pieces of railroad which run mostly east and west. Probably in that whole distance not fifty miles could be gained by using existing roads.

At least 300 miles of the line, at the Isthmus, would be through a country which is entirely unsettled except where the Panama railroad crosses it, and where in one or two places on the coast there are a few fishermen's huts. In the mountain ranges in the interior are some tribes of savage Indians, but no civilized beings.

The reader who will study the illustrations accompanying this paper, all of which faithfully portray types of natives in the countries to be traversed by the proposed Pan-American route, and their occupations and means of support, will be more strongly convinced than he could be by words alone of the lack of local traffic which such a railway would experience.

To give an idea of the probable cost of a railroad through this country, we can take the Panama railroad as a fair example. Its 47½ miles of road cost $8,000,000,—or $179,000 per mile. At the



NATIVE MEAT-MARKET AT GIRARDOT, COLOMBIA.

same rate this 300 miles of road would cost $53,700,000. The question naturally arises: "How does the Panama railroad pay such high dividends?" and the answer is, simply by charging enormous rates. A first-class passenger who crosses the Isthmus pays $25 in United States gold for his ride of 47½ miles. The building of that road made but little difference in the amount of freight carried in vessels around Cape Horn. To day its main traffic is in its passenger, mail, and express service, and the carrying of the highest class of freight. This road was built by American capital and

under American management, and the records of South American roads show that we can build roads there for less than half what the English spend on them.

The man who has not lived in a tropical swamp cannot properly appreciate that 300 miles of Isthmus. The water-supply in these swamps is ample for nine months of the year, but navigation in any direction is extremely slow and laborious. The water may vary from knee-deep to waist-deep until an abandoned creek channel, the current of which may be so sluggish as to be almost imperceptible, will suddenly show a depth of ten feet. The water is

A NEAT LITTLE HOME IN COLOMBIA.

THE HAY-MAKING INDUSTRY.

by far the least obstacle to a surveying party. Fallen trees, dense undergrowth, and vines, all plentifully supplied with thorns, make a mat through which scarcely a step can be taken without cutting a path. On a preliminary survey, dodging large trees, and avoiding all obstacles possible, a half-mile per day of line is good work. This requires four axemen at the front, equipped with "machetes," which are heavy knives from eighteen inches to two feet long.

There are species of palm which test these knives severely, and it will be an exceptional machete which escapes a thicket of these palms without at least one dent on its cutting-edge, and it is not uncommon to completely ruin a machete in five minutes' work. The foliage is so dense that it is rare that the engineer can see more than a hundred feet ahead. The sky is an unknown quantity, but mosquitoes, gnats, sweat-bees, ticks, chiggers, and carnivorous ants he has always with him.

The popular idea is that, since in this day of modern appliances and energy man can far outdo his ancestor of three or four centuries ago, he can overcome nature herself. Let us look at the

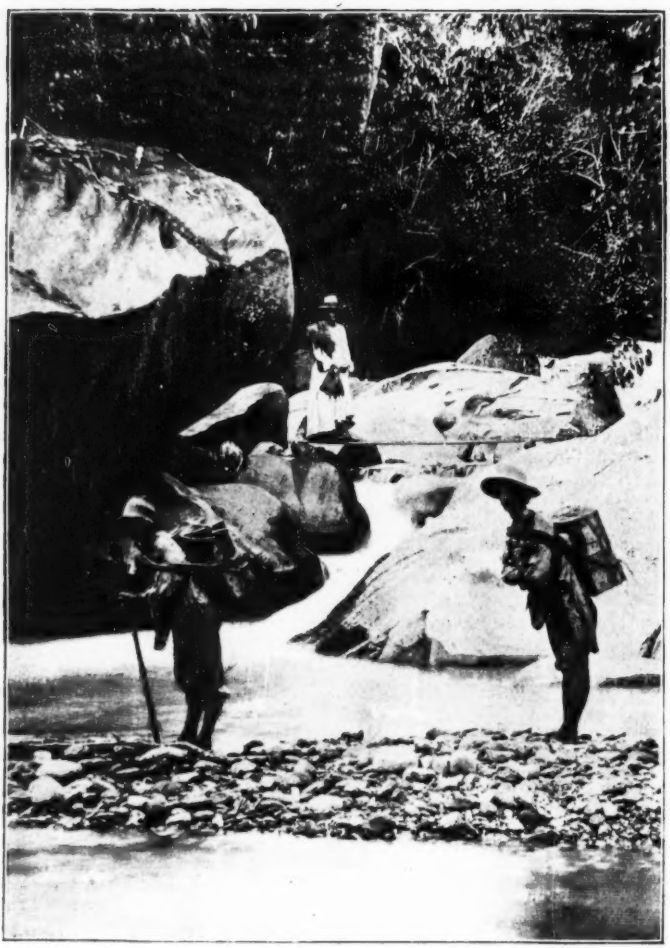
TYPICAL COLOMBIANS OF THE LOWER CLASSES.

[Laborers whose work is expected to furnish traffic for the Pan-American railway.]

history of this same strip of land. The Isthmus of Darien is but fifty miles wide. Balboa, in 1513, was the first civilized man to cross it. His men were loaded with armor and weapons, but they probably made natives cut a path for them through the tangled undergrowth. Of his 190 men but sixty-seven reached the divide; the rest were left behind sick or dead. The Spaniard returned, and later led 200 men who cut timber for four brigantines on the Atlantic shore, and carried the timber, with anchors, rigging. etc., over the mountains to a river which flowed to the Pacific. Here it was found that the timber, which had been cut near salt-water, was so worm-eaten as to be worthless. A new supply was cut on the ground where they were, but a freshet carried it off and cut off their road to supplies until they were nearly starved. A third bill of timber was gotten out, and they finally reached the Pacific after losing many men.

In 1849 there arose a demand for a ship-canal across the Isthmus. An Irishman named Cullen saw his opportunity for notoriety and cash, and published a book,—which had a ready sale for several editions, — in which he professed to have walked across the Isthmus of Darien several times, blazing trees to mark the way. He claimed that only three or four miles of deep cutting would be necessary to allow ships to sail from ocean to ocean. Cullen's story was so plausible that an English company sent a civil engineer, named

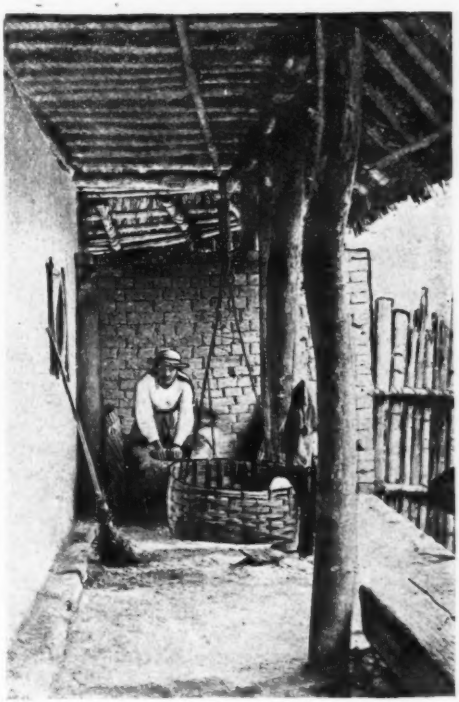
NATIVE METHOD OF CARRYING WATER.



AN ILLUSTRATION OF THE ABSENCE OF ROADS AND THE DIFFICULTIES OF TRAVEL IN THE COUNTRY INTENDED TO BE TRAVERSED BY THE PAN-AMERICAN RAILWAY.

Gisborne, to make a survey and report. The Englishman, not to be outdone by any Irish bog-trotter, professed to have made the survey, and published a book giving details, with map and profile. He located the summit of the divide at 150 feet above sea-level.

This official report caused four nations to send expeditions to explore this part of the Isthmus and examine the route. An English expedition started from the Pacific, and after cutting their way through twenty-six miles of dense swamp undergrowth, then gave up the attempt. An expedition composed of French and English left the Atlantic side, guided by both Gisborne and Cullen. The former could not find his own stakes, and the latter could find none of his blazed trees, for the very good reason that they existed only on paper. The ground did not correspond to the map, and they were lost so completely in the Caledonian valley that they finally returned to their ship after having gone six miles toward the interior. The Colombian party, exploring their own country, made as complete a failure as the other two.



NATIVE MODE OF GRINDING.
[With cradle in the foreground.]

To our fellow-countrymen alone belongs the credit of having crossed from ocean to ocean. The United States expedition, with twenty-seven men, under Lieutenant Strain, of the Navy, left the Atlantic coast with

VIEW ON THE ANTIOQUIA RAILWAY, SHOWING DENSE TROPICAL FOLIAGE.

ten days' provisions, relying on Gisborne's map. They soon found that the map was not to be relied upon, but persevered in spite of terrible hardships. The divide was found to be more than 1500 feet high, instead of 150. Before reaching it they passed a small Indian settlement, but on the Pacific slope they found no sign of human habitation until they were nearly at the Gulf of Darien. The party would all have perished but for the energy of Strain, who, when he found the majority of them almost unable to travel, went ahead with two of the strongest men, reached the Pacific, led a rescuing party of English sailors and natives, and overtook his starving men scattered along the road over which they had come, trying to return to the Atlantic. They were covered with ulcers and boils, and were little more than skeletons. Strain was reduced in weight from one hundred and forty-five to seventy-five pounds.

But it is not necessary to go back forty years to get an idea of the trials awaiting the company, or nation, which attempts to disturb nature in this tropical wilderness. The last ten years have

seen perhaps the most colossal and utter failure that the history of the world has recorded against the enterprise of mankind. The Panama canal was started ten years ago with the name of Count De Lesseps, the "Grand Frenchman," as his countrymen called him, at the head of the enterprise. He had built the Suez canal, and those who knew nothing of the Isthmus seemed sure he could build a canal anywhere. At an International Congress held in Paris his name and influence won a majority of the votes cast, in favor of his scheme to construct the canal at Panama in preference to at least six other proposed routes. He had no survey on which to base his estimates, and only a map and profile of the Panama railroad to give him any knowledge of the country. He insisted on a sea-level canal, without locks, and was ignorant of the fact that the tide on the Atlantic side is from twelve to eighteen inches, while that on the Pacific is from nineteen to twenty-one feet. He proposed to turn the Chagres river into the canal, and cited his Suez experience. He was not aware, though, that, while the yearly rainfall at Suez is 1.3 inches, that at Panama

NATIVE GOLD-MINING IN A REGION THROUGH WHICH IT IS PROPOSED TO RUN THE PAN-AMERICAN ROAD.

A NATIVE MARKET IN SOUTH AMERICA.

is 124 inches. In 1890 the rainfall at the Isthmus was 297 inches. In the month of July alone the fall was 52½ inches, or 11½ inches more than the annual rain and melted snow combined in Cincinnati.

The representatives from the United States had a survey and detailed estimate of the Nicaragua route, with map and profile, showing a faithful study of the country, but the public sentiment was in favor of Lesseps.

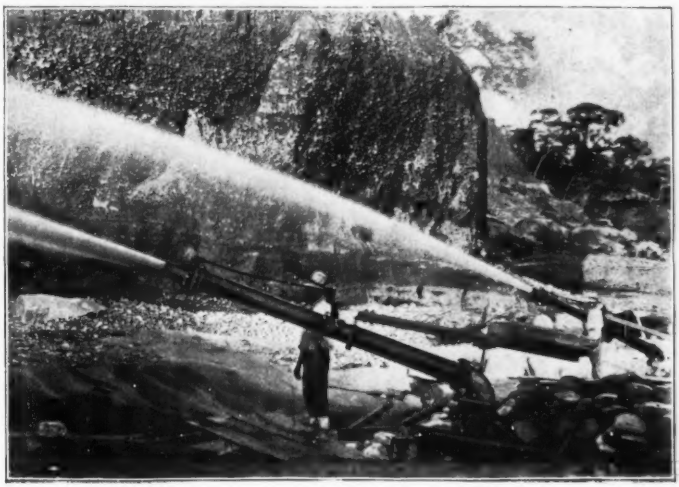
The result was a Panama-canal "boom." Men and money were crowded to the Isthmus with not even a preliminary line run. Soon it was found that it would not be safe to turn the Chagres torrent with its irrepressible

NATIVE BOY CHURNING.

cargo of mud and drift into a level canal, and an estimate was made to cut a separate channel for this stream to the Atlantic. The estimate for this was nearly equal to the entire original estimate for the canal. In eight years the money was all gone, and it is difficult to say just how much the sum total was, but it was not less than $240,000,000.

To day, if the attempt were to be renewed to build a sea-level canal at that point, it is said that less than one-tenth of the work necessary would be found done. Many of the deepest cuts have been almost filled by land-slides. Locomotives, cars, and costly machinery, representing millions of dollars, stand to-day on the Canal company's sidings, eaten by rust, and covered by tropical vines and undergrowth, a monument to the folly of the belief that nature is bound to succumb to modern man and his appliances.

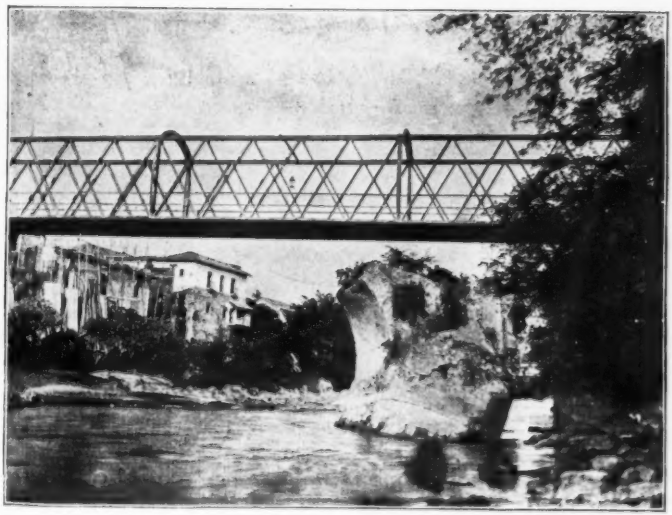
The maintenance of way of a swamp railroad in the tropics is no small item. The only accurate data which I have at hand gives an underestimate in the case of the first road mentioned, as fully half of the line was on high ground, was new, and needed comparatively little repair. The Antioquia railroad, in 1883, cost for repairs of track and bridges $2266 per mile. The Cauca railroad, in the same year, cost $3837 per mile. These two roads are in Colombia, and are sometimes mentioned either as future feeders



GOLD-MINING AT MALPASO.

THE POTTERY MARKET, HONDÁ, COLOMBIA.

CABLE BRIDGE ACROSS THE BOGOTA RIVER.



ANOTHER BRIDGE AT HONDÁ.

of the Pan-American railroad, or parts of its main line. On the Antioquia road, if the undergrowth were cut at the beginning of the rainy season, less than two months' rain was sufficient to form an arch of green trees thirty feet high, leaning over the track so as to shade it completely.

The constant change from dryness in the day to soaking moist-

A SOUTH AMERICAN MINER.

ure at night, even in the dry season, would soon ruin the best of timber, but nature furnishes a still quicker means of getting rid of it, in the shape of an ant or wood-louse, which is careful not to mar the outside of his domicile, but will patiently honeycomb the inside, until what looks like a solid twelve-by-twelve stick is but a shell from $\frac{1}{8}$ to $\frac{1}{4}$ inch thick, filled with dust and ants. The native timber suffered so much from the inroads of these pests that, upon

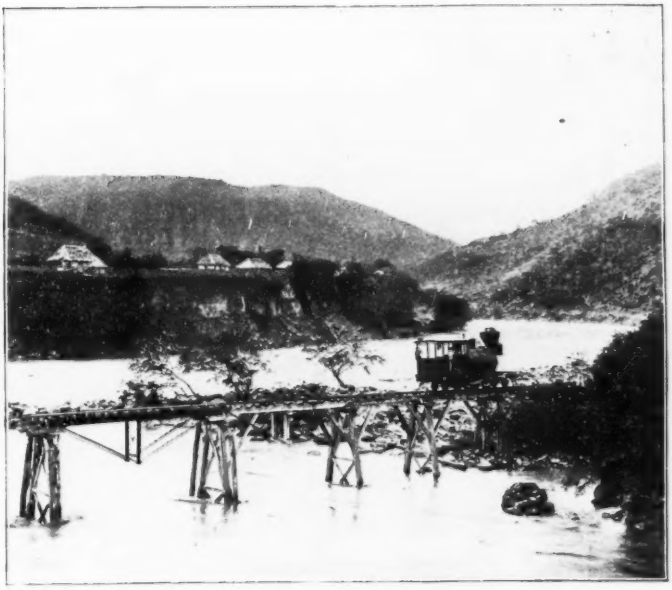
hearing that yellow pine was used in Panama to avoid them, a trial of it was made on the Antioquia road. Georgia pine had to be shipped by way of New York, at a cost of nearly $100 per thousand feet, board measure, when put in place. When I left there, the first of my yellow pine trestles was being replaced. It had been built less than four years.

NATIVE COLOMBIAN WOMAN.

It is amusing to see with what confidence even civil engineers will write of a territory which they have never seen. An engineer in Peru wrote not long ago to the *Railroad Gazette* (New York): "Bogotá, the capital of Colombia, can be reached by a line up the valley of the Magdalena to Hondá, from which place a road is built to the capital. Average cost per mile would be quite moderate." I have been up and down that Magdalena river often, lived

TROPICAL VEGETATION IN COLOMBIA LOWLANDS.

[Type of growth which can be kept in subjection only by constant vigilance, at great cost.]



BRIDGE OVER AQUAS CLARAS, HONDÁ.

on its banks for years, and made a survey for a railroad from a point above Hondá to Bogotá, and I can assure the writer that from the mouth of the Magdalena almost to Hondá—a distance of 600 miles—the valley is an abominable swamp, varying from twenty to one hundred miles in width, with oases of high ground few and scattered. The cost of railroad construction through it would be not less than $50,000 per mile for a very temporary road, and the traffic would not pay half the cost of repairs.

At Hondá there is a narrow-gage road about sixteen miles long, connecting the navigation above and below the rapids, but not running in the direction of Bogotá. From Hondá to Bogotá there is a mule road, but it is not possible to drive a vehicle of any kind over it. On the plain of Bogotá there is a railroad twenty-two miles long, running from Bogotá toward Hondá, which has been built within a few years. My estimate of cost of a narrow-gage road from the Magdalena to Bogotá, ninety-six miles, was about $6,500,000, in Colombian money. This line had thirty-five miles

TRANSPORTATION OF A LOCOMOTIVE BOILER.

of 4 per cent. ascending grade, and curvature as high as 20 degrees.

In conclusion, I would say that in my opinion the Gordian knot of the Pan-American railroad problem lies in that crooked Isthmus of Panama and the country immediately south of it. At present it is certain that, if the road were built through the entire extent of the proposed line, no company or syndicate on earth would maintain it for the traffic which might pass over it. That tropical country is too sparsely settled, the people have too little need for exertion, and the governments are too unstable, to justify the risk of capital in any such venture. Reference may again be made to the pictorial arguments accompanying this paper, which can hardly fail to convince any but enthusiasts how unpromising is the field and the people for the building of an expensive railway.

REFRIGERATION FROM CENTRAL STATIONS.

By John E. Starr, M. E.

THE time and talent of the modern engineer have been largely occupied with efforts to simplify and cheapen operations involved in securing the primary necessities of domestic and business economy,—water, light, heat, power, transportation, communication, and the preservation of food. Capital and business acumen have gone hand in hand with the engineer, and so rapid has been the progress made, and so well has the public been educated in the advantages of the resulting improvements, that the luxuries of yesterday have become the necessities of to-day.

The "central plant," with its distributing arms reaching to the smallest consumer, has become a fixture in metropolitan life as permanent as the maintenance of pavements and sewers. The record of the development of methods for the distribution of water and illuminating gas is now deemed ancient history in engineering annals, and our attention is claimed for the progress of electrical distribution for light and power, the transmission of speech, the installation of compressed-air plants, and the attempts to distribute hot water and steam for heating. A new chapter may now be added to the already voluminous record of "central-station" work: the history of the distribution of refrigeration by underground pipe-lines from a central plant. The term "distribution of refrigeration," by the way, may not be a scientifically appropriate expression. In all of the other operations referred to something is sent to the consumer, as water, heat, or power. The refrigerating process is one of collection rather than distribution. For, instead of sending to the consumer something (as light or water) that he desires to make use of, the refrigerating system takes away from him something that he desires some place to be deprived of,—namely, heat.

The pipe-line refrigerating system may be termed the complement of steam-heating. In the latter process a vapor—steam—is sent out from the central plant, and, by means of branches, conveyed to the heat-transferring surfaces,—*i. e.*, radiators; there it is condensed into a liquid—water—and in so condensing gives *out* heat; the water is then returned to the central plant, where it is again vaporized and again sent out to the consumer.

In the refrigerating process a *liquid* of low boiling-point (such as ammonia) is sent out, and, by means of mains and branches, conveyed to the heat-transferring surfaces,—that is, the "expansion coils." Here the liquid is released from pressure and, owing to its low boiling-point, is vaporized, so *taking up* heat; the resulting gas carries the heat in a latent form back to the central station, where the heat is "squeezed out" by pressure and transferred to the sewer through the medium of the cooling water used on the condensers. The gas is again reduced to a liquid and again sent out. It will thus be seen that the working fluid is merely a vehicle to convey heat from the central station to the consumer, in the case of steam-heating, and to convey heat from the customer to the central station in the case of refrigeration.

The older method of conveying heat from the inside to the outside of a refrigerator is necessarily clumsy and its expense uncertain. The cutting of ice in winter, its storage through the summer, its transfer piecemeal to the refrigerator, the large amount of room required to hold the ice needed to take up the heat rapidly enough and to transfer it to the outside in the resulting ice-water are all serious disadvantages.

Up to the introduction of the pipe-line system only those who required large amounts of heat to be transferred could afford the appliances necessary to effect such transfer without using ice as an intermediary. To such large consumers of cooling power the introduction of ice-machinery has been of incalculable value. In the brewing, meat-packing, dairy, and cold-storage warehouse industries, the refrigerating-machine saves annually millions of dollars, and renders possible operations on an enormous scale. To secure to the smaller consumer the benefits, and to the vendor the profits, of mechanical refrigeration was the problem of the pipe-line engineer. The general economical advantages required to be preserved may be stated as follows:

First, the realization of enormous economy by operating in such a way as to transfer the heat directly from the customer to the central station without using ice as an intermediary.

Second, the great economic advantages in distribution.

Third, the general advantage of producing power on a large instead of on a small scale.

Fourth, the commercial advantage of being able to offer to the smallest consumer of refrigeration all the benefits and economies of artificial refrigeration now obtained only by large consumers.

To explain more specifically the first of the above considerations, it may be said that all refrigerating-machines have two ratings, one known as its "refrigerating capacity" and the other as its "ice making capacity." The latter is usually placed at the outside at only 60 per cent. of the former. That is to say, if we have a refrigerating-machine that will produce as much cooling power as could be obtained from 100 tons of ice, this machine, if placed directly at work on the space to be cooled, would manufacture only sixty tons of ice. This may be more readily understood when it is remembered that in ice-making the water which is to be frozen has first to be cooled by the machine from a temperature of 80° or 90° F. to the freezing-point before the process of congelation begins. This loss, together with the absorption of heat in and around the ice-making tank, makes up the 40 per cent. difference, and this is why all refrigerating-machines are catalogued commercially with the two ratings mentioned.

In the pipe-line process the refrigerating-machine is put directly at work on the spaces to be cooled. Where a central plant has the equivalent of 100 tons of ice to deliver to its customers, the artificial-ice plant has, with the same machine and the same expenditure in coal and engineer's wages, but sixty tons to deliver. This leads to the second consideration. The sixty tons of artificial ice with the expense mentioned are only delivered at the factory door. The 100 tons of the station have been delivered to the customer.

The delivery of ice, even to large consumers, is one of the principal factors of cost, while to smaller consumers, say of from 50 to 500 pounds per day, the delivery is by far the greater portion of cost. The service of ice requires usually a team of horses, a wagon, and two men for delivery in a comparatively limited district, and the cost of delivery by this method usually ranges from fifty cents per ton for the larger consumers up to $2.50 per ton for the users of small pieces of from ten to 200 pounds per day. This large "operating cost" of delivery, which to the ice-dealer is an item of expense, becomes to the pipe-line company an item of profit. The upkeep, or repair account, is little if any more by the pipe-line method than by the horse-and wagon system of delivery.

The methods by which these economies are preserved have been worked out to a satisfactory commercial result in two cities of the United States. The experiment was tried on a commercial scale first in Denver, Colorado, and later in St. Louis, Missouri. In the former city the first street pipe-line was laid in the spring of 1889

and in the latter in 1890. In both cities the lines have been gradually extended until a considerable part of the business portions is now reached by the refrigerating-mains. The advantages and the economy of the system have stood the test of time, and similar plants are projected at other points, such as Kansas City, Dallas, Brooklyn, Atlantic City, and Cincinnati.

As before stated, the operation of the pipe-line depends on the use of a suitable working fluid, having a low boiling-point. The fluid used in the majority of refrigerating-machines at this day is anhydrous ammonia. This is the fluid used in pipe-line work. At a temperature of 80° F. it remains liquid under a pressure of about 150 pounds, while at a temperature of one atmosphere it boils at about 30° below zero. Any refrigerator whose temperature exceeds 30° below zero, then, will transfer heat into this *liquid* and boil it into a vapor, provided the pressure in the "boiler" is kept no higher than one atmosphere. As it usually is not required to hold a refrigerator, even for freezing purposes, below 20° F., a higher pressure in the "boiler" may be permitted. For example, the boiling-point of ammonia at twenty-eight pounds pressure above the atmosphere is only 15° above zero.

An elementary pipe-line system, then, would only require a pipe strong enough to safely hold liquid ammonia under a pressure of about 150 pounds to carry the liquid to the refrigerator, and a second line, capable of safely holding ammonia gas, under a pressure of from one to two-and-one-half atmospheres, to take the expanded gas back to the factory after it had been "boiled out" in the piping placed inside of the refrigerator.

Commercial adaptability requires a more complex system of piping. In Denver and St. Louis the method of laying the pipe-line is as follows: A trench is made in the street, from three to six feet deep, at the bottom of which a half-section of twelve-inch vitrified sewer-pipe is laid, bedded in concrete, with the concave side uppermost. The iron pipes conveying the ammonia are carefully joined together and laid on saddles resting in the vitrified-pipe channel. After a thorough test for leaks the upper half of the twelve-inch vitrified pipe is laid on and a cement joint made with the lower half-section. The ammonia-pipes are thus entirely inclosed in a water-tight and practically indestructible conduit of vitrified-clay, the object of which is twofold: it gives protection and long life to the iron pipes by keeping them away from moisture and contact with the earth, and makes possible the prompt detec-

tion and location of leaks. Man-holes are provided at street intersections, and at other suitable points, where cocks in the main lines are provided, to permit the shutting off of certain sections, and to control generally the operation of the mains.

The ammonia piping system, as far as the mains are concerned, consists of a "liquid line," conveying the liquid ammonia under pressure; a "vapor line" or "return main," carrying the expanded gas to the factory, and a "vacuum line," the object of which will appear presently. The size of these main lines is regulated by the distance to which the service is to be carried and by the maximum amount of duty expected. At intervals of about thirty or forty feet a service branch, generally of half-inch pipe, is brought out by a T from each of the main lines. These three service-pipes are run together, usually through an eight-inch conduit, to a stop-box at the sidewalk, where suitable stop-cocks are placed, as in water- and gas-service. The three branch lines are carried on inside of the building to the customer's refrigerator. A coil or grid of piping is placed in any convenient position (usually on the side walls) inside of the refrigerator. This is called the "expansion coil" and corresponds to the radiator in steam-heating. At one end the expansion coil is connected with the liquid branch, and at the other end it is joined to the vapor branch. A suitable valve regulates the flow of ammonia from the liquid branch into the expansion coil. The latter communicates freely with the vapor branch. A constant suction in the return or vapor line is kept up in the central station, keeping the pressure in the expansion coil down to from one to two atmospheres. The regulating-valve is slightly opened and a tiny stream of anhydrous ammonia flows into the expansion coil. There, being relieved from pressure, it boils or vaporizes at a very low temperature. The heat to produce this vaporization comes from the interior of the refrigerator. The gas resulting from this evaporation returns by way of the vapor branch and return main to the central station, carrying with it the heat it has absorbed from the interior of the refrigerator. At the central station the gas is reduced by pressure and cooling to a liquid, which is again sent out into the liquid main. The amount of liquid allowed to flow through the regulating-valve is governed by the size of the box, the temperature required, and the general character of the service. Sufficient expansion coil is provided in every case to boil out all the liquid admitted. The liquid, being held under pressure up to the wall of the refrigerator, cannot expand or produce any

cooling effect, so that no cooling power is wasted in the mains or branches. The only place where heat is taken up or cold produced is in the refrigerator, where it is paid for.

An important disadvantage met with in steam-heating from a central plant—that of large loss by radiation from the mains—has no counterpart in the refrigerating system, as in the latter no power is lost on the way.

The vacuum line is a vital portion of the system, for without it continuous operation could not be secured, nor could necessary repairs be made. The branches from this line are connected at each box with the liquid and vapor branches. Normally they are shut off from these branches by suitable cocks. In case of necessary repairs in or about the piping connected with the refrigerator, or of extensions required of the service inside of the building, or of a removal of the refrigerator, the liquid and vapor branches are shut off from the main lines at the stop box, and the cocks into the vacuum line are opened. At the station a vacuum pump connected with the vacuum main is started, and all the gas contained in the section required to be cleared is pumped back to the station and saved. A ten- or fifteen-inch vacuum is usually produced in addition to pumping back the gas. The piping may then be safely opened without the slightest smell of ammonia resulting. The vacuum line is also cut into the main line at man holes and other points, so in case of a leak the injured section may be rapidly cleared of gas. This line may be used as a "by pass" line to bridge one or more blocks, in case of injury to any portion of the other main lines.

The pipe line has so far been laid with such great care, and the development of proper fittings and valves has so far progressed, that little if any difficulty has arisen from leaks. In fact, in only two cases has a leak on the main lines occurred,—once each in St. Louis and in Denver. With the aid of the vacuum line these leaks were promptly stopped with little difficulty and slight expense.

To operate the pipe line successfully it is necessary to have at the central station a suitable refrigerating-machine. There are now in the market two types, compression and absorption machines, the general characteristics of which are familiar to any reader on engineering topics. Almost any machine in the market could successfully operate a pipe-line system, but for one fact. In ice-making, or in cooling a definite amount of space, such as a cold-storage ware-house or brewery, the operation of the machine is at a constant rate; that is to say, when one pound of liquid is sent

out, a pound of gas is at the same time received by the machine, and the rate of such sending out and reception is constant. The refrigerating load on the pipe-line, however, is irregular, and its variations may be compared to the shifting load of an electric-light plant. One of the difficulties apprehended when the pipe-line business was projected was the difficulty in handling with the present type of machines such a duty as is indicated. The changes in the load occur at unknown intervals, and the amount of change could not be predetermined. The absorption machine was, therefore, chosen, as it more readily admitted of adaptation to this particular duty. In this machine, as is well known, the ammonia is distilled out of its combination with water or aqua-ammonia, and, still under the pressure produced in the distilling process, it is run through surface condensers and compressed into liquid. This liquid, after having performed its refrigerating duty and in so doing expanding into a gas, is returned to the machine and received into the water out of which it was originally driven ; it is then again distilled. It is important that this process of distillation should be kept up at a regular rate.

The pipe-line, however, calls for an irregular use of the product of the machine. This is easily handled with an absorption machine by storing up ahead, in reservoirs, considerable quantities of anhydrous ammonia, so that, if the line calls for a rate of outflow of the ammonia faster than the rate of distillation, the call may be met So far, this duty could be performed by a compression machine. But it is in the irregular flow of the gas back from the refrigerators that the real difficulty exists. With the absorption machine it is simply necessary to interpose between the absorber and the still pump a reservoir of sufficient capacity to hold in reserve a suitable amount of strong aqua ammonia. Another reservoir is provided, holding a surplus amount of weak aqua ammonia. The gas, therefore, may come back either rapidly or slowly, and it is only necessary to use sufficient of the reserve quantity of the weak aqua ammonia in the absorber to receive the returning flow of gas. The resulting product of strong ammonia is stored in the other tank to be distilled at leisure. The combination of these two tanks and the anhydrous-ammonia reservoirs, therefore, makes a complete system to allow for "come" and "go." The refrigerating service may vary within wide limits from hour to hour, while the distilling process may go on at a constant rate and the pressures on the main lines be held constant. In fact, this storage system in cold weather

or with a light load makes it possible to stop the process of distillation altogether for a considerable time, while the process of refrigeration is steadily kept up.

The pipe-line system is elastic and admits of a wide number of applications. The bulk of the work so far performed by it is to take care of the regular storage-box for hotels, restaurants, saloons, butchers, butter and commission houses, etc. The particular advantages to this class of consumers are the low and regular price, the maintenance of lower temperatures than can be procured by the use of ice, cleanliness, relief from all care in the management of temperatures, and the room saved. The latter item amounts to from 20 to 40 per cent. of the total cubic contents inclosed by the insulating walls.

The principal hotels and restaurants and down-town butcher-shops in St. Louis and Denver are using this system in their storage-boxes. But the applications of the system do not end here. In many hotels, cafés, and saloons ice is required for water-pitchers and to crack up for mixing beverages. In such cases a miniature brine-tank is provided, through which the expansion coils connecting with the pipe-line are run. Molds of suitable size are placed in the brine, and the operation of ice-making is carried on just as at the large ice-factory. Where small amounts of ice are needed for cracking up, a small insulated reservoir is provided and the expansion pipes are placed close to the sides. Water is then poured into the reservoir, and ice forms on the expansion coils and extends towards the center of the reservoir until a solid mass is frozen. This is chipped out as desired, and new water added from time to time.

Another important branch of the business is supplying cold water for large stores, factories, and offices. The installation for this service consists of a water-tight insulated tank, having at the bottom a coil through which the hydrant water is passed on its way to the taps. About a foot of water is poured in on top of this coil, and just underneath the surface of this water the expansion pipes are placed. A sheet of ice five or six inches thick is formed by the action of the expansion coil, thus keeping the water coils constantly surrounded with ice-water of low temperature. The city water so cooled may be then carried by insulated piping to taps in any portion of the building. The cooling of soda-water fountains is effected in the same way. The manufacture of ice-cream is also more easily accomplished by the aid of this system. Other branches

of business are also supplied, as the manufacture of perfumes and chocolate confections.

Among the luxuries furnished by this system may be mentioned the cooling of living-rooms, which, in such a climate as that of St. Louis, proves a great luxury. The refrigerating company there started in with contracts to reduce the temperature of cafés and dining-rooms twenty degrees below the outside temperature. No difficulty was found in cheaply reducing the temperature even to a lower point than this, but sanitary considerations, and the comfort of the frequenters of such places, determined that a difference of from ten to fifteen degrees between the inside and the outside temperature was the most satisfactory. It is interesting to note that the same piping used for the ammonia cooling service in the summer is used for steam heating purposes in the winter. It happens that in neither Denver or St. Louis do the pipe lines reach any of the hospitals, though the benefit of their use in such institutions is apparent.

As in every other central-station enterprise, commercial success in this depends on the volume of business that can be reached with a reasonable investment. The financier must look further than the successful attempts of the engineer in performing his duties of working out the mechanical problem. In this connection it may be said that Americans are the greatest users of refrigeration in the world. The poorest of our citizens are customers of the ice-man. The refusal of an employer to provide cold water in summer for the most humble of his workmen would result in a strike, while the lavish use of ice in all things connected with bodily refreshment is a matter of surprise to the European visiting our country.

The results in St. Louis and Denver have shown that the business may be successfully carried on with an annual return no greater than $7000 for each mile of mains. In the business districts of the larger cities the demand for refrigeration per mile would be much greater than this. A canvass of five miles of streets in the business portion of St. Louis, for example, showed a present consumption of ice amounting to $170,000 per annum, basing the cost of ice (delivered) at the low price of $4 per ton. A canvass of three miles in Kansas City shows a demand of $72,000. In the better residence portions of these cities the consumption of ice is estimated, at $5 per ton, at from $12,000 to $16,000 per mile. In the middle-class section the annual demand, at the same price for ice, is from $8000 to $12,000 per mile. It is safe to say that any American city of 20,000 inhabitants could readily support the pipe-line system.

CONDITIONS OF FORESTRY AS A BUSINESS.

By W. J. Beal, M.S., Ph.D.

FORESTRY is a business, like agriculture,—an industry which is concerned in the production of a soil crop. It is the art of managing a wood crop so that it will make the best harvest of timber, in the shortest time, at the greatest profit. Forestry differs from agriculture, however, in that it takes many years for the crop to mature, and the crop is then a complicated one. Forestry in the United States as a defined business is now in its earliest stages,—chaotic or undeveloped. In its most perfect condition forestry is not a single science or art, but combines relations to several sciences and arts. On its scientific side it touches botany, chemistry, geology, meteorology, physics, geography, and entomology; on the art side it touches horticulture, arboriculture, lumbering, and protection from fires.

In parts of Europe the growth of timber is already well systematized, but knowledge of the subject in all its details has been of slow growth. More than a hundred years ago a few alarmists in Europe prophesied an approaching dearth of timber. This agitation helped to induce economy in the use of timber and to delay the evils predicted. Without giving the strictest attention to systematic arrangement, we may note some of the chief attainments by the leading countries of Europe in the management of forests and the methods adopted to accomplish such results.

It would seem that government ownership and control of much of the forests in the old country gave a great advantage over our newer country, where "private enterprise" accomplishes almost everything. There, even the woodlands of corporations and of individuals are subject to the laws of the country, which specify how much may be cut in each year. These laws are enforced by officials well educated for the business. Forests are systematically inspected and reports made concerning their condition and needs. The inspector acts as "a paternal adviser" to all owners of forests. In the words of a recent American consul to Austria-Hungary: "The owner of forest land in Austria must exercise extraordinary care not to be guilty of trespass upon his own lands." How different the feeling of owners of land in the United States! In the

country above referred to the array of forest officials of various grades maintained numbers nearly 32,000 persons. In all of these particulars the fact must not be lost sight of that wages are much lower, and interest on investments much less remunerative, than in the United States.

The large number of officials who must pass rigid examination makes it possible and even necessary to maintain numerous schools to keep up a supply of skilled men. The encouragement of profitable employment induces pupils to patronize the schools, which give laboratory or practical work, often in the forests, as well as lectures in the class-room. To some extent these subjects are taught in other schools than those for the special object of educating foresters. These officials usually serve for life and are pensioned in old age or in case of disability.

By dint of great energy of a few persons in this country, attention has been called to the greed and dishonesty of men who steal timber from the public lands and to the evil effects of removing vegetation from mountain slopes. Many instances of the same kind have been enumerated in Europe, where the evil effects remain as a warning to newer countries. The cost of reclaiming some of these waste places has been great. In this reclamation seeds from the scattering trees cannot be relied on to furnish seedlings for the new growth, but nursery-grown stock must be well set and afterward properly cared for. Experience has led to the formation of many rules in relation to forest management. For example, on sandy soil and on steep mountain slopes timber can only be cut in narrow strips or thinned out. Grazing among timber is never permitted. Stringent rules in regard to igniting fires in or near forests are enforced.

Between 1860 and 1887 France reforested over 250,000 acres of mountain lands at a cost of $30,000,000, the State paying one-half. In 1887 the total annual appropriation for the forestry department of France was $5,000,000. Here the people of the United States may well take warning. How much more economical it would be to spend a little money now in preventing devastation than to suffer the consequences for a time and then possibly spend enormous sums in restoring the forests to the mountain slopes.

In Germany about 25 per cent. of the entire area is devoted to forests. Of this amount about 32 per cent. is government land; 15 per cent. belongs to communities; 1.3 per cent. belongs to charitable and other institutions; 2 per cent. belongs to corporations;

and 48 per cent. belongs to private parties. Without the supervision of State officials "a reckless devastation of forests would be the consequence,"—just the condition we are experiencing in most regions of our own free country. In the Eiffel district the mountain slopes were reforested and otherwise improved at the expense of the government, though much of the land belonged to communities.

A chief director of forests in Germany in writing to a United States consul says: "You are certainly quite right when you speak of the importance of forest culture for the United States, but allow me to express my belief that no earnest work in that direction will be accomplished there. The culture of the forests proceeds too slowly to suit your countrymen, and the profits are not forthcoming soon enough. In my opinion good results from forest culture can only be had in the United States when the government shall have taken the matter into its own hands." Dr. Otto von Hagen says: "The forest is a trust handed down to us from past ages, whose value consists not alone in the income derived from wood, but also in the importance which it exerts, through its influence on climate and rainfall, or land culture. Its importance is not merely a question of the present day or of the present ownership, but is also a matter which concerns the future welfare of the people." For these and other reasons it has been determined that it is a duty to interfere by legislation with the waste of timber.

Think of the time required to grow trees of certain species fit to cut for important purposes. In Germany the age for cutting oaks is 150 to 180 years; beech, 100 to 120 years; Scotch fir or birch 30 to 100 years, though for some purposes, of course, trees are cut when much younger. One of our consuls to France in 1887 observed that "forests are much more easily destroyed than replaced, for in three years, from 1788 to 1791, almost as large an area in France was deforested as has been reforested in the last ninety years, although much attention has been paid to the subject during this time."

The older and more thickly-settled countries of Europe have all passed through the stage in which many of our States have but recently passed or are now passing. Their land in most instances was well covered with forests. They cut and fired and wasted as we are doing, and have long been aware of many of the evil effects of this practice. To what extent shall we learn and profit by their mistakes?

Under the circumstances what can the people of the United States accomplish? In what ways can we best secure a reform in forest management? Legislation, whether State or Federal, will accomplish little, until there are enough stalwart persons thoroughly interested to continue under adverse conditions to work for the success of a better management of lands in forests or lands which ought to be covered with forests. Something may be done by forest commissions, but too much is likely to be expected of them, and to save expense somebody will advocate their abolition, —and somebody sooner or later will succeed. The value of forestry commissions consists chiefly in giving advice and in educating the people.

Tree-planting on a large and expensive scale is not likely soon to be so skilfully conducted that satisfactory profits will be apparent. But notwithstanding, trees of every kind should be planted in many places, and the sooner the better for us all. Probably not one in a thousand now knows enough about the subject to proceed intelligently to take the best care of his forest or to reclothe the land with timber in the most economical manner. Those who try the experiment should be able to wait.

Over a hundred years ago some persons in Europe were foolish (?) enough to plant a few white pines from North America. In the language of our time they would be known as "cranks," and yet who shall dare place a sufficiently high estimate on the value of that simple experiment, for it has demonstrated that our white pine is one of the best of trees to grow for timber in that country. We need men in every county of every State who will have enthusiasm and foresight enough to plant a few trees in places where there may be a prospect for growth a long time without molestation. Before these experiments are completed there will be many anxiously waiting to profit by the results.

We live in a comparatively new country, where our fathers and grandfathers cut down and burned the finest of trees to make room for crops and pasture. We have been taught to destroy trees and not to save them,—much less to replant. The arguments for preserving the virgin forests of a new country are by no means all on one side, and no one should expect the trees to be preserved. In most cases the profits of holding are too small to pay for the investment.

Michigan once had about 150,000,000,000 feet (board measure) of standing pine, which was believed to be well-nigh inexhaustible.

Those now living find remaining only comparatively small tracts in the back counties. Even with what might be considered good management in a thinly inhabited country, where lumber was cheap, it was soon found next to impossible to preserve this timber, however much the owners might desire to do so. In many seasons the fires destroyed as much pine as the woodman's axe. Dead pines must be cut to save them, and the débris was almost sure to burn and the fire to spread to the standing trees. To some extent the same condition of things prevails with regard to the "hardwood" trees, though in most cases these are not so likely to be destroyed by fire. In a business way there are men now spending much time and money in defending their remaining pine lands from fire. But more system is needed, and the care should be more general than it ever has been.

The study of European methods and results in forestry by competent men is not enough, says one writer.* It is not even the most important thing for us. Nothing can be very useful to us which is not based upon careful study of the conditions peculiar to this country. We must have in time a system of American forestry if we are to avoid serious disasters to our national interests and civilization. The forestry of this country must be the product of growth, which has as yet scarcely begun. It will be developed by continued and widespread observation, and by constant comparison of the results of practice. It is necessary to remind ourselves that no useful system of forest management can be originated or created by legislative enactment. There must be special knowledge and national good sense regarding the needs of this country, behind forestry laws, or they will be useless and mischievous.

It is important to understand the value of great areas of growing trees on the surrounding cultivated land, and to know in what respect they check fierce winds, prevent rapid evaporation of moisture, or encourage late frosts in spring. But the possession of this knowledge is not likely to induce men to save trees or to plant trees for the benefit of persons owning farms in the surrounding townships or in other counties. Here is one of the best of reasons why the State and Nation should take an active part in the management of forests.

It is difficult to induce most persons to understand fully the results of a timber famine. They have heard more or less of this

* *Garden and Forest*, Vol. 1., p. 26.

talk for years, but they believe the day is yet far distant when our people will suffer much inconvenience from lack of timber. They argue that, as timber becomes scarce and more expensive, less of it will be used. We shall burn coal for fuel, and use more iron and steel. Transportation will be cheaper, and timber can be transported for long distances. The use of the land to produce various grains, grasses, fruits, and vegetables will help to pay higher prices for timber.

In the moister portions of our country, when the original forests were cleared away, seedlings and sprouts in immense quantities sprang up to contend for every foot of available space. In cutting away the valuable timber there are usually large numbers of "young things" up to six inches or more in diameter, which, if protected from fire and other destroyers, have already made a fair start toward renewing the forests. Too little care is usually observed in protecting this young growth, which is admitted to be of no value at the present time. Because there are no dollars in them now, the proprietor is likely to let them go to waste. In very few instances in moist climates would it be necessary to plant trees started in the nursery.

The writer has often been asked by bright young men of no resources except their active brains and hands: "What is there in this country to encourage a young man, who must earn his living as he goes along, to make a specialty of forestry? I like the subject, and if I saw a good living in the business I should run the risk and go ahead." I am free to say that, so far, work in this field seems to be done gratuitously.

A few persons in our agricultural colleges have done a little in this direction,—mainly to call the attention of students to the magnitude and importance of a study of forestry. Before any one of us thought much about trees, the courses of study in these colleges were replete to suffocation with subjects of seeming importance. Elective courses are expensive. The writer has twice given a course of lectures daily for twelve weeks to members of the senior class of the University of Michigan—or to those who elected forestry. A course of parasitic fungi runs parallel with that on forestry, and only one of the two can be elected. No doubt there have been similar reasons in the other schools to prevent giving more attention to forestry. But if we are interested and make the effort, we can all find some opportunities for this work.

Lectures at farmers' institutes now held in many States afford

some opportunity. But here the indifference of the hearers tempts us to select other subjects. Vividly does the writer call to mind one occasion at an institute in a new county in which he spoke of the importance of preventing forest fires. The first one to lead in the discussion was a farmer living in the neighborhood, who won the applause of the audience when he said of these fires: "They are the best friends we have in clearing up the country."

The more students know about trees, the more they are likely to be interested in this subject. The things to be learned are the different species, their names, their anatomy and physiology, their rate of growth and geographical distribution, their special uses in the arts and in nature, how to raise trees from the seeds, how to plant and where to plant and why, and especially how to take proper care of them after setting. He who fully understands the structure and functions of roots will never be seen carting living trees with roots exposed to dry wind and sun for miles along the highway. Students may be set to investigating the effects of pasturing a wood lot by noting examples of those pastured and those left to themselves. They may estimate the amount and value of an acre of good, medium, or thin forest, and note the time required to produce it. The effect may be noted of trees as a shelter along the highway, or near dwellings, barns, and sheds. Other questions are: Why are certain trees found growing in swamps and others on dry land? Why are there no pines or cedars in some neighborhoods, and no beeches or maples in others?

Besides the means suggested for aiding the cause, there are others: If the programs were judiciously prepared and well carried out, the celebration of Arbor Day by school children would have a tendency to awaken an enthusiasm among the people, but usually the exercises consist mainly of quotations from literary authors,—scraps of poetry, history, and sentiment,—rather than any substantial information pertaining to the needs of forestry. The establishment of an arboretum, even a small one on some of the farms of enterprising people, and more especially at each agricultural college and experiment station, would help to educate and interest the people. We cannot soon expect to see an Arnold arboretum in every State, but the beneficent influence of that garden has already reached thousands of miles.

Associations for securing the protection of certain private natural scenery help to educate every one who sees the reserves. Botanic gardens containing shrubs and trees are likely to increase

in numbers, each good one lending encouragement to others. So of herbaria, and especially of museums of plant products which should contain no end to interesting specimens of timber, not only those which were well grown, but likewise all manner of monstrosities. The writer a few years ago collected and placed in position a unique collection of this kind, and, considering the cost, it was more attractive than an ordinary museum of fossils, minerals, or stuffed animals. Who can tell the good results likely to occur to forestry from the establishment and maintenance of the Jesup collection in Central Park, New York?

Several books have appeared that are worthy of notice, but none of them can be compared with "The Silva of North America," by Prof. C. S. Sargent, the first four volumes of which have been published. In several States reports have been issued by Forestry Commissions or forestry associations, or special bulletins on the subject have been published by experiment stations. The United States government has, through Mr. Fernow, the efficient head of the Forestry Division of the Department of Agriculture, for some years past been active in advocating measures of importance in relation to forestry. Bulletins and reports and gratuitous lectures and frequent conferences with congressmen have all had their effect in awakening an interest in this subject. There are several journals, notably *Garden and Forest*, which have exerted a good influence in behalf of tree protection, and such articles as THE ENGINEERING MAGAZINE has published lately on the great waste of timber still in progress are of value in properly educating the public mind.

From the condition of things here outlined it will be seen that the growth of an interest in forestry must be slow for some time yet, but I anticipate very great changes in the sentiment of our people and the formation of salutary laws by the close of this century.

AN EARLY ENGINEERING MAGAZINE.

By Hyland C. Kirk.

THE industrial and technical literature of to-day is so vast and so closely interwoven with the lives and work of all classes of our people that it is not easy to imagine a time, within our own century, when one or two small weekly journals practically supplied the demand for periodical publications devoted to the whole field of engineering. There had to be a beginning in this work, however, as in all other departments of human activity, and it may interest some of the readers of this Magazine to devote a few minutes to an examination of the contents of an early publication, which, while possessing merit, must have proved a labor of love rather than a source of profit to the publisher.

The Glasgow Mechanics' Magazine, a weekly journal printed and published by W. R. M'Phun, was established in January, 1824, and was one of the earliest periodicals devoted strictly to engineering science. *The Philosophical Magazine*, first published in London by A. Tilloch, in 1798, was devoted chiefly to translations of scientific articles from the French, while the Edinburgh journals of Brewster and Jamieson treated more of the progress of discovery in general science than of applied mechanics. *The American Mechanics' Magazine* began publication on February 5, 1825, and appeared for the last time on February 1, 1826.

The *London Mechanics' Magazine* was founded in the year preceding the establishment of the Scottish journal,—in August, 1823,—but was hardly equal to it on the score of attractiveness. This is conceded in a controversial article printed in the London magazine on July 10, 1824, in the following style: "The Glasgow magazine, though not sold for the same price, is printed on a finer paper and in a more showy manner than ours; but then it does not, on an average, contain one-half the quantity of matter, nor one-half the number of illustrative engravings, that the London magazine does."

To this the Glasgow journal replied: "Let any one compare the two magazines, and he will find that 'on an average' there is as much matter in the one as in the other, and that the London magazine contains no illustrative engravings at all, but only woodcuts, whereas the Glasgow one has, in general, a very fine illustra-

tive copper-plate engraving, and a number of woodcuts alternately in each successive number." These engravings would be likely to attract any reader of to-day so fortunate as to meet with a copy of this truly excellent periodical. It appears to have been edited anonymously during the year 1824, but the management was changed in the second year, as indicated by the following head from the magazine :

THE GLASGOW
MECHANICS' MAGAZINE,

CONDUCTED BY

A Committee of Civil Engineers and Practical Mechanics.

" From scenes like these old *Scotia's* grandeur springs
That makes her lov'd at home, rever'd abroad :
Princes and lords are but the breath of kings,
' An honest man 's the noblest work of God.' "—*Burns.*

No. LIII. *Saturday, 1st January*, 1825. Price 3*d*.

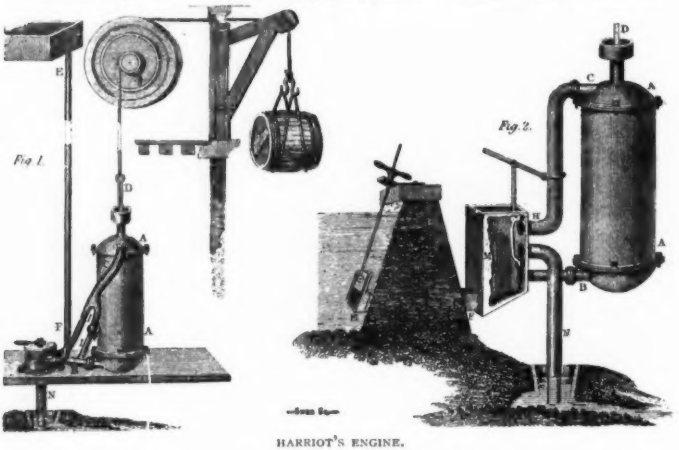
This magazine ran through 143 weekly numbers, making five volumes, when it was discontinued. The only valedictory to be found is in the motto quoted on the title-page. This motto was customarily changed from week to week, and in the last number this quotation from Mr. Brougham suggests, doubtless, something of the publisher's state of mind in relinquishing his work :

> The people themselves must be the agents in accomplishing the work of their own instruction. Unless they deeply feel the usefulness of knowledge and resolve to make some sacrifices for the acquisition of it, there can never be any reasonable prospect of this grand object being attained.

The five volumes were republished in 1835–36, and these reprints are occasionally to be met with, but a copy of the original edition is a rarity indeed. The magazine is of interest now chiefly (1) as showing the condition of engineering science three-quarters of a century ago ; (2) as showing the origin of modern-class instruction in mechanics ; and (3) as illustrating inventions peculiar to the Scottish people.

At that period great activity prevailed with regard to mechanical improvement and invention, stimulated by the successes of Watt, Franklin, Arkwright, Fulton, Bell, Stephenson, Davy, and others. New motors and new applications of motive power were being diligently sought for. Though steam was a favorite subject of experiment, no field was left unexplored. Two illustrations are reproduced of engines to be operated otherwise than by steam, which at that time seemed to possess some promise of value.

Harriot's siphon engine, used for raising and lowering weights, combines the power of the siphon with the direct pressure of a column of water, so that each alternately acts on the upper and lower part of a piston within a cylinder, reversing the siphon at each change. The two figures, illustrating the apparatus under slightly different applications of the power, will give a sufficiently clear idea of its construction. In each *M* represents the reservoir from which the water flows to the upper or lower part of the cylinder, as the operator adjusts the valves. The power of this engine is equal to a column of water of the same diameter as that of the cylinder, and equal in length to the height of the head together with the depth of the siphon-pipe below. The principle has had

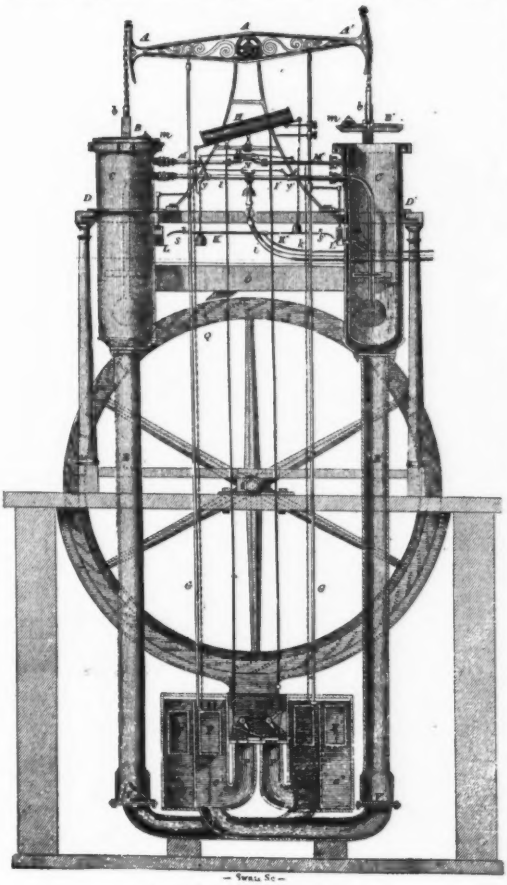


HARRIOT'S ENGINE.

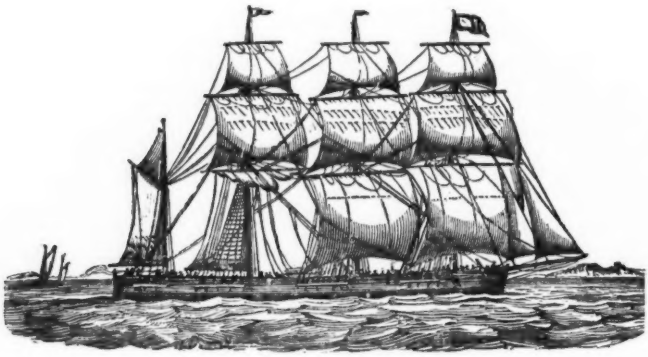
later applications in certain forms of the hydraulic press, elevator-engines, and other machines.

The pneumatic or gas-vacuum engine, the invention of Mr. Brown, of London, was designed for raising water, and as shown in the engraving, for turning a water-wheel *Q*, by water discharged from the tank *O*. By the combustion of gas in the cylinders *C*, *C* lighted alternately by external flames at *L*, a vacuum is produced alternately in each cylinder, forcing the water through the pipes *P*, *P*, and up the mains *E*, *E*, whence it is discharged into the tank. The floats *F*, *F*, which rise and fall with the surface of the water in the chambers below, act on the walking-beam above to cover and uncover the cylinders. In the language of the description

given, "It is therefore the extinction of the flame by closing the top of the cylinder which actually produces the vacuum; while at the same instant the water from below rushes up with vast rapidity to fill its space in the cylinder; at the same time driving out the gas of the combustion by means of the small valves in the cover opening outwards. The water is discharged from the cylinder into the trough by admitting the atmospheric air through the horizontal pipes *M*, *M*." The editor, commenting upon this apparatus, regards the result as produced partly by the rarification of the air, though three-fourths due to the combustion of watery vapor, which occurs when the gas is put out and the cylinder begins to cool. He adds: "Properly speaking, Mr. Brown's engine is a steam-engine, and not a vacuum engine, as it has been called." This criticism, however true it may be, illus-



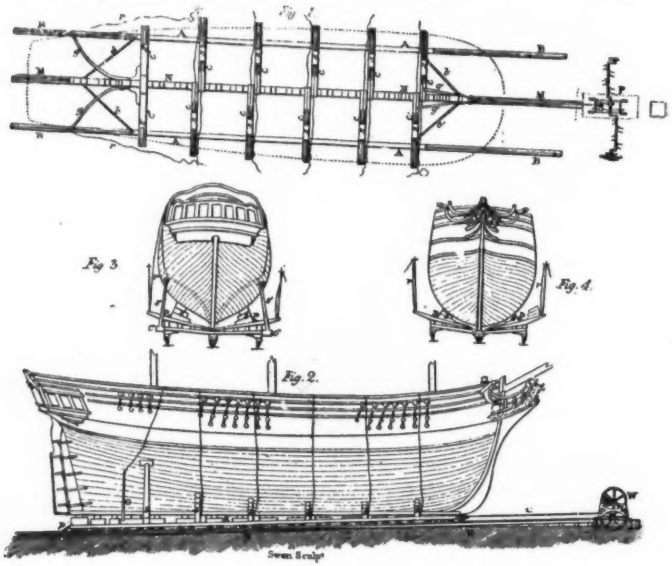
BROWN'S GAS-VACUUM ENGINE.



THE FOUR-MASTED AMERICAN SHIP "COLUMBUS."

trates probably something of the zeal manifested at the time for Mr. James Watt and his great invention.

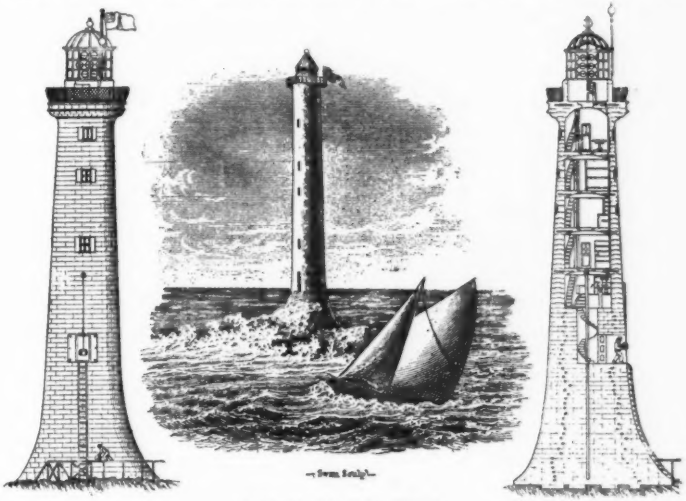
Among devices of an eminently practical character illustrated in the magazine, and which for the most part are set forth with



MORTON'S PATENT SLIP.

sufficient clearness to show their workings without further explanation, are the screw-machine of Angus Mackinnon, of Glasgow, the printing-press of Mr. Medhurst of London, and Morton's slip for repairing vessels. Each of these well illustrates the stage of the art to which it belonged, at the time.

Many references are to be found to ships and nautical affairs. A woodcut of the *Columbus*, the largest ship then afloat, appears in the magazine for November 13, 1824. This vessel was 300 feet long, with 50 feet breadth of beam, and 30 feet depth of hold. She registered 3690 tons, and carried a cargo on her first voyage from Quebec to Liverpool of 6300 tons of pine deals and staves. The



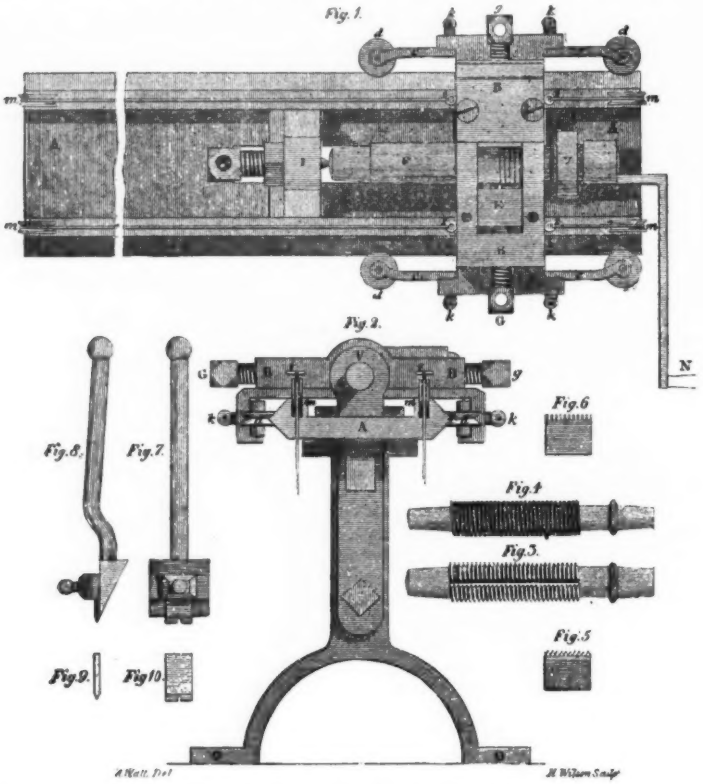
THE BELL ROCK LIGHTHOUSE.

voyage began September 12, and anchor was cast at 3 P. M. on November 1. A work of greater interest to the nautical world is that of the Bell Rock lighthouse, built during the first dozen years of the century by Robert Stevenson, on the famous Inchcape rock off the east coast of Scotland. Still one of the great lighthouses of the world, it is unique in the fact that revolving bells are used as well as a revolving light in the turret, the former being of great service in warning vessels during fogs.

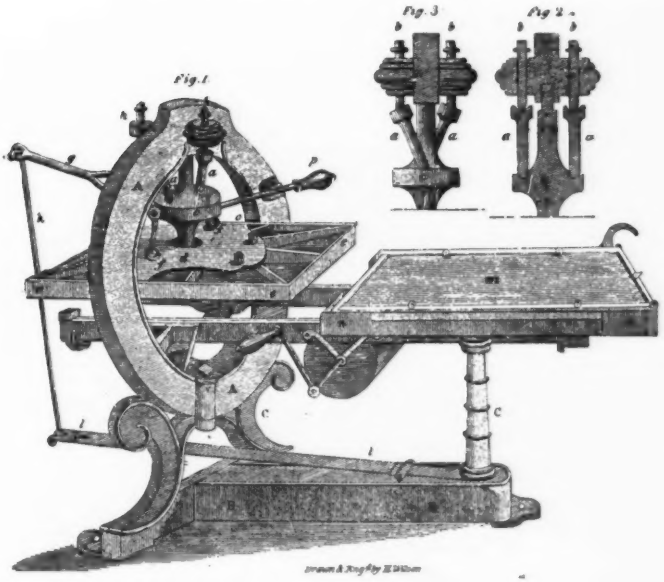
The great interest in the subject of steam at that period is shown in the fact that, while some twelve articles scattered through the

volumes are devoted to barometers and atmospheric pressure, six to bridges, twenty-seven to the art of bleaching, ten to clocks,—including clepsydras,—twenty-nine to electricity in its various forms, thirteen to the subject of light, ten to heat and thermometers, and eleven to weaving, no less than fifty-eight are devoted to steam and the steam-engine. Twenty of these articles refer in some way to steam navigation, embracing discussions and controversial letters as to who invented the steamboat, the claims of Fulton, Bell, Miller, and others being considered.

There is a report of the meeting held on Wednesday, November 24, 1824, in the city of Glasgow, "to consider the best means of



MACHINE FOR MAKING AN ORIGINAL AND PERFECT SCREW.

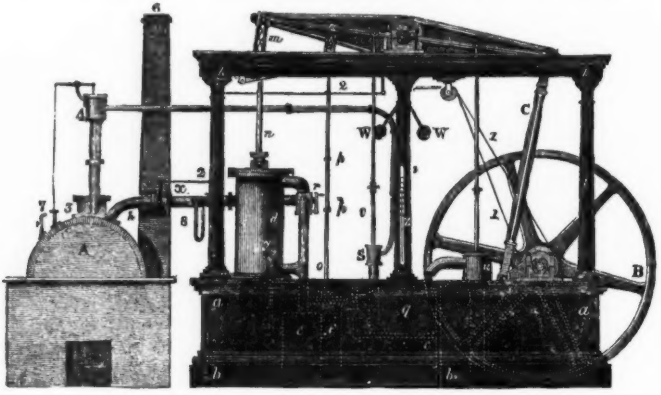


MEDHURST'S IMPROVED PRINTING-PRESS.

promoting a subscription for erecting a monument to the memory of James Watt." Mr. Watt was a native of the neighboring city, Greenock, and made his great invention while working at his trade as an optician in Glasgow in the winter of 1763-64. He applied for a patent in 1768, after thoroughly proving the efficiency of his device, through the aid of Dr. Roebuck, by erecting an engine at a coal-mine at Kinneil. London, Edinburgh, Greenock, and some other towns had already paid their tribute of admiration to the genius of Watt, but Glasgow, as if verifying the saw, "a prophet is not without honor save in his own country," had remained silent. This tardiness was explained at the meeting by the Lord Provost, who presided, in the statement that "many gentlemen entertained the idea of promoting the erection of one grand monument to his memory in Westminster abbey, in preference to anything of the kind here or elsewhere. This idea, however, on trial had not succeeded, and would therefore fall to be superseded by (he trusted) the more successful efforts of this day." Nearly every speaker who followed, including Professor Jardine, Mr. Monteith, Kirkman Finlay,

Mr. Ewing, William Smith, Dr. Thomson, Mr. Houldsworth, and Dr. Ure, had been a personal friend of Mr. Watt, and the interest is in nowise lessened by their accounts of conversations with him.

"When speaking of his great and uncommon qualities," said Professor Jardine, "I cannot forget his modesty and his simplicity of manners. Speaking once upon his great invention, I heard him say 'that, when it was analyzed, it would not appear so great as it seemed to be.' 'In the state,' said he, 'in which I found the steam-engine, it was no great effort of mind to observe that the quantity of fuel necessary to make it work would forever prevent its extensive utility. The next step in my progress was equally easy, to inquire what was the cause of the great consumption of fuel; this



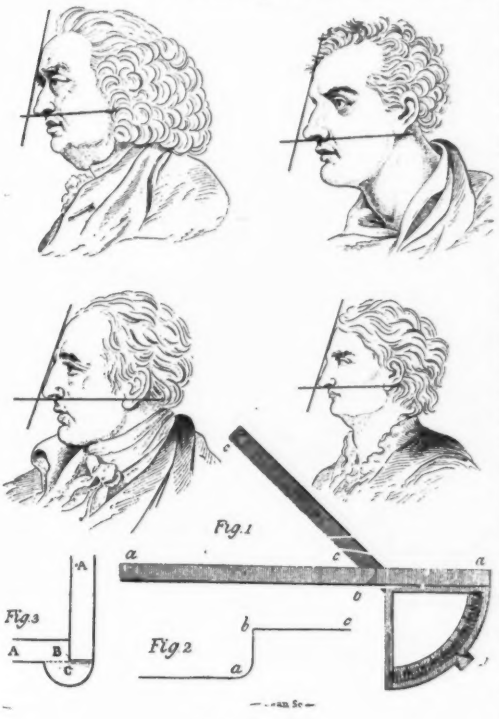
WATT'S TRUE MONUMENT—THE STEAM-ENGINE.

too was readily suggested, namely, the waste of fuel which was necessary to bring the whole cylinder, piston, and adjacent parts from the coldness of water to the heat of steam no fewer than fifteen to twenty times in a minute.'"

Dr. Ure referred to a conversation on a kindred subject: "'As to the latent heat of steam,' said Mr. Watt to me, 'it was a piece of knowledge essential to my inquiries, and I worked it out myself in the best way that I could; I used apothecaries' phials for my apparatus, and by means of them I got approximations sufficient for my purpose at the time. With them I ascertained the two main facts about steam: first, that a cubic inch of water would form about a cubic foot of ordinary steam; and secondly, that the

condensation of that quantity of steam would heat six cubic inches of water from the atmospheric temperature to the boiling-point. Hence I saw that six times the difference of temperature, or fully 900 degrees of heat, had been employed in giving elasticity to the steam; which must be all abstracted before a complete vacuum could be produced under the piston of the steam-engine.'"

Dr. Ure, in a lecture given in aid of this monument fund, on December 20 following, well illustrated the greatness of Watt's invention by showing that the great pyramid, weighing 10,666,666 tons, and which, according to Herodotus, employed in building the whole available population of Egypt for twenty years, could have been built by means of the steam-engines then existing in Great Britain in less than five hours. "The knowledge of the laws of nature," said he, "arms our feeble hands with her most gigantic forces. How many populous and flourishing cities have been created by the genius of Watt! What were Birmingham, Manchester, Nottingham, Leeds, Preston, Glasgow, and many others, before his engine gave them vitality? And what would become of them were it to disappear?"

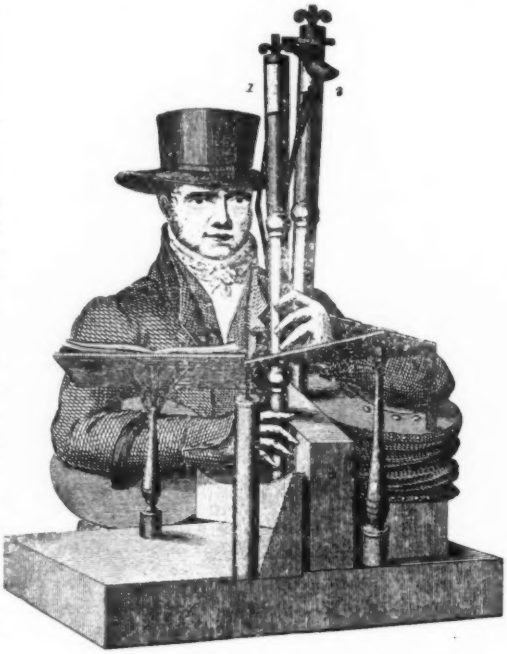


THE FACIAL ANGLE.

The following prophecy uttered toward the close of his lecture

seems to have been verified reasonably soon: "The time is not far distant when chariots winged with fire shall be seen flying over metallic pavements through all the populous districts of the empire, transporting travelers and merchandise with amazing smoothness and velocity."

Though Mr. Watt's patent on the steam-engine included a claim for propelling carriages, he never constructed a locomotive. As the changes in mechanism from the engine which he did make to the railway engine were not radical or difficult, a number of locomotives by different inventors were soon forthcoming. Four of the articles on steam refer especially to locomotives.



HATTON'S CHAMBER FLUTE-ORUM.

In the last volume of the reprint is an account of the opening of the railway between Liverpool and Manchester in 1829, and also of the unfortunate accident in which Mr. Huskisson, home secretary in the British cabinet, accompanying the Duke of Wellington and Sir Robert Peel, was run over by the "Rocket" engine. This accident seems to have been due largely to the inefficiency of the reversing gear to stop an engine moving at a comparatively slow pace. The "Rocket" had been constructed by George Stephenson, the successful competitor in securing the prize offered on that occasion for the best locomotive. Mr. Stephenson, deeply grieved

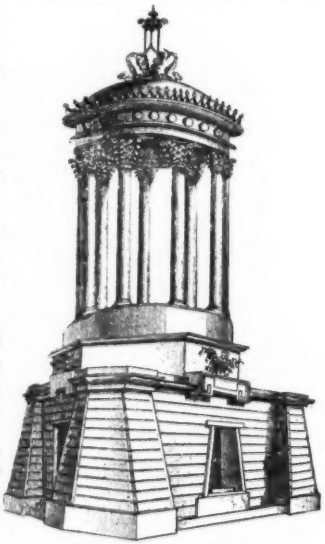
at the accident, placed Mr. Huskisson on board the Northumbrian engine and, acting as engineer, conveyed him fifteen miles in twenty-five minutes, a most marvelous achievement at the time. Mr. Huskisson died that night at Eccles. The greatest speed on the trial trip of trains was one mile in 2 minutes and 6 seconds, the slowest speed one mile in 4 minutes and 57 seconds. There were eight engines in the procession, each drawing four carriages and from sixty to ninety persons in each train. The first conveyance of freight along this railway did not occur until December, 1830, when the total weight, "including eighteen wagons and engine," was eighty tons.

Natural history notes, mathematical problems, chemical experiments, questions of hygiene and the personal equation, are numerous throughout the volumes. Under the last head is a table of voice compass as compared with the range of musical instruments, deemed sufficiently important to be adopted by Knight in his "Mechanical Dictionary"; also the "faciometer," an instrument by which those who wish to be particular may measure the intellect of their friends. This instrument is shown in connection with the profiles of Dr. Johnson, Lord Byron, Sir Isaac Newton, and John Kemble.

In discussing the proposed monument to Watt, another question was incidentally raised as to whom the merit belonged for founding mechanics' institutions. A writer, "W. G." (probably Mr. Gardner, secretary of the mechanics' class), had occasion to say: "Anderson's Institution, of which I have the honor to be a member, has the distinguished and undisputed honor of being the parent of all the numerous Institutions that are now established in the kingdom for the instruction of mechanics; and it ought also to be the first in doing homage to the memory of that departed worth and talent which was fostered by the very hand that laid its foundation. The very man that founded this noble Institution twenty years before any similar one existed was the friend and companion of the illustrious Watt, and, had not our venerable founder, Professor Anderson, required his assistance in a very small matter, the steam-engine of Watt, and the consequent wealth and prosperity of our country, as well as the glory of this day, would never have had an existence. . . . To Professor Anderson may be traced the origin of all those Mechanics' Institutions which have since arisen in Britain, an honor which has hitherto been ascribed to another individual."

This called out a rejoinder from a correspondent "B." (Hugh Barclay, Esq.), who said: "The world has hitherto imagined Watt to be the improver of the steam-engine, and Dr. Birkbeck the founder of schools for the education of mechanics. But henceforth, on the showing of W. G., the 'distinguished and undisputed honor' must be awarded to Professor Anderson. I hate controversy much, but I hate injustice still more, and will not see Dr. Birkbeck (the 'individual' alluded to had W. G. chosen to speak out) thus gratuitously stripped of his well merited honors."

Dr. Birkbeck was then living in London and did not answer letters addressed to him on this subject, even those from his own supporters. The question seems to have been very thoroughly settled by a writer who subscribed himself "Aliquis." It appears that Mr. Anderson, professor of natural philosophy in the University of Glasgow for forty-one years prior to 1795, was accustomed to visit the workshops of artisans and to give them such information as was likely to be beneficial in their respective trades. The idea then occurred to him that, if a class were opened to which they could be admitted, it would greatly promote their knowledge in the different arts. Accordingly he opened a class upon Tuesdays and Thursdays at 8 P. M., to which the public were admitted. In a short time, "within the walls of Glasgow College, was there a large class of operative artisans receiving instruction in a science which before that time was inaccessible to the public." So "to Professor Anderson may be traced the origin of all those Mechanics' Institutions which have since arisen in Britain."



MONUMENT TO BURNS AT AYR.

Among the architectural illustrations is one showing a monument to Burns,—a structure which was located on a "brae" near the "banks" of "Bonny Doon," with "Allowa's auld haunted kirk" on the opposite side of the road, a little to the right.

THE PAST AND FUTURE OF ENGINEERING.

By Gordon B. Kimbrough.

IF an observant person were asked what art is most nearly related in its evolution to modern civilization, he would answer without much hesitation by saying that it is the art of the engineer. Esculapius, in the practice of his art of healing, gave pills, or their substantial equivalent, thousands of years ago; and though medical men have made some discoveries since then, and added an indefinite number of new remedies to the materia medica, their art has not radically changed. It is to be feared even that they have made much less progress than they are ready to claim; for though they assure us that the average duration of human life has been prolonged, the difference has not been sufficiently great either to be observed in history or to invalidate a certain counter claim that might be advanced. It may be assumed that, if it be true that human life has been prolonged, the improvement is due more to civilized living habits and the physical evolution of the race than to medicinal skill. We hear a great deal of learned talk about *bacilli*, and the doctors tell us that they have discovered the germs of disease. The very editors of some even of the most pestilential newspapers enlarge upon this subject as a means of displaying their scientific accomplishments. But Professor Koch failed signally in the attempt at utilizing his discovery in the treatment of consumption; and his failure has left him open to the suspicion that he has not discovered the germ of disease after all, but only the germ of the maggot, that final product of every fatal disease. We cannot say with certainty, therefore, that the art of healing has gathered much from human progress in the sciences of civilization, though in the face of all the claims presented in its behalf it may seem heretical to doubt. Surgery is unquestionably modern in its highest exploits, and quinine has proved to be a wonderful discovery; but the surgeon's control over human affliction is exceedingly restricted, and there is good reason to suspect that quinine was the contribution of a less than semi-civilization. Indeed, so questionable have been the triumphs of the art of healing that were due to generally advancing knowledge that it is not many years since the quack who announced himself an "Indian

doctor" became a successful alchemist, able to transmute his wampum and feathers into refined gold. Even now the doctors think it necessary to make war on those eccentric persons who believe that faith is better than physic.

But let us leave the medical men alone. They are having enough to do in the protection of their *bacilli* without assuming any additional responsibility, and the arts more intimately related to the engineering art in their structural features will serve the purposes of illustration just as well as the art of healing. They may not be quite so old as the art of the medicine man, but they are old enough.

Turn, then, and look at the art of building. But the very first glance at architecture carries the eye almost beyond the circumference of modern civilization, and causes it to rest upon a renaissance, a medieval, or an antique world. It is doubtful if there is anything distinctly modern in the art of architectural building except its aberrations and its metallic ligaments. The best probably that any new architect will ever be able to accomplish on lines that are not engineering rather than architectural will be found in modern modifications and adaptations of ancient forms. It is a question if architecture, strictly considered, has not been rather corrupted than refined by its contact with modern civilization. We shall not find in the art of building anything to take from the engineer his preëminence in the development of civilizing forces.

Perhaps painting will serve us better. But here, again, we have something that is confessedly not modern in any of its essential features except possibly its choice of subjects, or a partial dependence upon certain mechanical processes that tend rather to the degradation than to the elevation of art. The modern painter, like the modern doctor, may insist that he has become learned; but it must be said in the one case as it was said in the other that the fruits of his learning are not clearly manifest. The works of the Grecian painters have long since perished; but we know that they were thought superior to the works of the Grecian sculptors even in form, and the works of the sculptors still remain the standard of excellence by which all modern works of sculpture must be tried. They are the models in drawing, too, for modern painters. We must assume, therefore, that, when the modern painter tries to measure his growth by a comparison between his own works and the works of the medieval or rather renaissance period, he is not looking far enough backward to estimate his true proportions. As to

the art of sculpture itself, however skilful a few of the modern sculptors may have become, it is rather an antique than a modern art, unless it may be said that modern sculpture differs from ancient sculpture in its inspiration. The former is more monumental than the latter, and it makes its demigods out of commonplace heroes.

In this vein we might survey almost the entire field of art, including its literary annex, and, except among a few of the minor decorative arts, find little or nothing that can be claimed as distinctively modern and free from the necessity of borrowing from antique achievements. But there is one exception. In the engineering art we find an example of a constructive industry which the Romans and other people of antiquity practised. Yet from their achievements we can borrow little or nothing that is worth crediting. The Roman roads have remained a marvel of constructive energy and great resources down to the present time; but they represent an agency of transit and transportation that is passing away, and which is destined at no distant day to disappear utterly from the territory of every civilized nation. So, too, are we bound to believe that the ancients had great mastery over mechanical forces, that they were prolific in mechanical expedients at least. They could not otherwise have reared the vast structures that have been the wonder of the world. But their expedients would hardly serve a people who can lift great ships out of the water like toys. As to the dike-building engineers of antiquity who set the River Po on edge, their achievement was not sufficiently commendable for imitation, although the people of the Mississippi valley have not yet escaped from their malign influence.

Against this general disparagement of the engineering performances of antiquity may be set the aqueducts of Rome; but it cannot be admitted that these devices for supplying water to large cities illustrate a good principle in engineering. They are imitated in modern times only because the political octopus always sets itself against both progress and economy. In the first place they were conceived before the steam engine and the pump had made accessible the vast reservoirs of unadulterated and cool water hidden beneath the surface of the earth, and are therefore fundamentally wrong. In their modern adaptation they are simply sewers for conveying the drainage of barn-yards, and fields dotted with dead animals, for domestic consumption in towns, and on its way their supply is further contaminated by the floating carcasses

of dead and rotting fish, decaying vegetable matter, and every conceivable filth that river water contains. We want no contaminated river-water in towns except for mechanical purposes; and the quantity needed could be supplied without any elaborate and costly adaptations of the stone or brick aqueducts of Rome. For all domestic uses except washing and cleansing we should have well-water drawn through separate pipes and distributed through separate reservoirs. The city of Brooklyn has both sources of supply, and it obtains approximately 50,000,000 gallons daily of river- and swamp-water, properly proportioned with barn-yard and dead animal solutions, and 25,000,000 gallons of pure well-water. But owing to the Brooklyn politicians' relish for mixed drinks probably, the total supply is distributed through a common reservoir. The people of Brooklyn, like the people of Hamburg, are not permitted to take even their drinking water straight.

But the dike builders and the aqueduct builders of modern times are antique survivals; and they hardly count among the army of engineers who are leading in the latter-day industrial march. The field of the modern engineer is widely diversified, and his preëminence over his ancient prototype is due to his versatility.

It is easy to understand the causes for the almost complete enfranchisement of the modern engineer, and for his distinctively original characteristics. They are found in the first place, after the invention of the steam-engine, in the larger use of iron as a material in construction, and in the second place in the discovery of explosives. The steam-engine had almost revolutionized the art of the civil engineer before the beginning of the last half of the current century; and the destructive power of cannon balls and other long-range missiles has compelled the art of military engineering to find cover against something more formidable than the missiles of the catapult or cross-bow. The discovery of explosives, too, has had its effects, and very remarkable effects, in the evolution of civil engineering, making possible the execution of works which the Romans could not even have conceived. The removal of the obstructions to navigation in Hell Gate, the modern treatment for such obstacles as Scylla and Charybdis, furnishes a case in point.

The engineer of to day is to be called the chief workman of the period. He not only builds our railways, opens our mines, and protects us, or pretends to protect us, from the destructive floods

of our rivers, but he has taken such pervasive possession of the art of house building that the architect is compelled to play only in the rôle of the decorator. What lunatic Cæsar, baffled at the attempt at subjugating Scotland, would ever have conceived of a cantilever bridge to span the obstructing arms of the sea, or of penetrating the Highlands with steel roads equal to the transportation of an average Roman army in a few hours to the spot where stands the house of the more modern but still ancient Johnie O'Groat? Or what daft Pericles, had he been with Hendrick Hudson in New York Bay, would ever have thought it possible to find on the swampy surface of lower Manhattan Island a suitable foundation for a half-dozen repetitions of the Acropolis piled the one upon the other? The engineer alone of all other men is doing work in construction that leaves antiquity so invisibly in the rear that it is unable to offer a single suggestion that can promote the success of his operations.

Yet the work of even the modern engineer is only just begun. He has been erecting merely the skeleton of a figure yet to be clothed with flesh and covered with arteries through which will flow the life blood of a newly quickened being. The forces long known have only paved the way for the introduction of a new force destined to render all past achievement preliminary to the work to come. All that steam has done it will now be called upon to repeat infinitely through a new agent until its power is made almost as pervasive as the air.

Electricity may be said to have given a new birth to the art of engineering. Heretofore the engineer has not been considered an inventor in the sense that renders inventions patentable. He has been an inventor in his way, the inventor of structural processes and of mechanical expedients; but when it comes to the construction of machines to render his operations fruitful, he has been dependent upon the exertions of men working in a distinct field of construction. It may almost be said, indeed, that his devices have been supplementary to the work of the inventor; for though the railway preceded the locomotive, just as the ship preceded the steamship, the earliest railway was a device hardly to be dignified with the name engineering until the invention of the locomotive had called for its extension across rivers and through mountains. So, too, with the art of military engineering. It was the cannon ball and the destructive fire of musketry that developed the earthwork, the mine, and all that science of siege and defense that directs

the hand of the military engineer. But the relations of engineering to invention must be radically changed now that electricity has come. The new agent will compel the engineer and the inventor, like the engineer and the architect, to pool their issues in a single head.

This may need a little amplification. The steam-engine, notwithstanding its wonderful resources, is a very unwieldy piece of workmanship. It has been trained to run rapidly enough along lines of parallel steel rails, and it can move all over the world in the interior of a steamship. But elsewhere it is a chained giant, only to be moved with difficulty, and its ability to distribute its forces is limited to the length of a shaft. Its field, therefore, is restricted, and it is fitted only for special tasks. But the electric motor is fitted for the performance of any task which machinery can be made to perform, while, at the same time, the appliances for the distribution of electrical power are at once so simple and so complex that there is more occasion for the inventor than for the engineer—as engineering duties have been heretofore conceived—to preside at the installation of the plant. In this fact we find a suggestion of what the engineer of the future must become if he would master his art and be in the highest degree successful. He must not only distribute the power, but he must enable it to work through an incalculable number of implements of his own device.

The performance of agricultural labor, soon doubtless to be attempted by electricity unless the farmers are the slowest men on earth, offers a chance for illustration. There will be no difficulty in conveying the electrical current to the farms. It will run along the highways, and transport both the farmer and his produce in its passage as soon as he will provide the way; but when it has been delivered at the farm, it will enter a field which is yet to be cultivated. After it leaves the highways, where it can be made to operate through adaptations of machinery already devised, it must be trained to work at the plow, at the harrow, and at every implement used by the farmer that can be operated by any other agency than the hand. But the machinery for farm labor is yet to be prepared; and it will be a poor triumph for the engineer to be able to say that he has provided the expedients for distributing the power, and left to other men the task of making it in the highest degree useful.

Hereafter the invention of machinery must be a part and a chief part of the training of the engineer. Men speak of the elec-

trical engineer, of the mining engineer, and of the mechanical engineer as well as of the civil and the military engineer. But we could speak with just as much propriety of the architectural engineer, or the marine engineer, meaning by the latter designation not the men who drive marine engines but the men who build ships. Strictly speaking, there are but two kinds of engineers in the world, the civil engineer and the military engineer ; and it is curiously suggestive of a lack of intelligence on engineering subjects when we see the latter placed in charge of the duties of the former by official authority without as much preliminary experience as would be necessary to make a good house carpenter. In the distant future, when all the swords have been beaten into plowshares, there will be but one kind of engineer extant. He will be the mechanical or industrial engineer, and, known simply as the engineer without any specializing prefix, he will be the most ubiquitous being on earth.

For the present, the most promising agent for the industrial engineer is electricity. We know not what new forces the future may bring forth ; and while so much remains to be done in utilizing the resources of electricity, we have little reason to care. It may be that men will one day visit the planet Mars, if they care to waste time on a 40,000,000 mile excursion through space. But the living generation can find abundant entertainment nearer home. Our explorations for the present may very well be limited to the rural districts of our own earth, and the engineer should not be satisfied until he has carried electricity to every rural household.

ELECTRICITY.

Conducted by Franklin L. Pope.

IN an article in the *Independent* Professor F. B. Crocker, of Columbia College, says that the young man who takes up the study of electrical engineering with the intention of working hard, and who takes a real interest in his work, is almost sure of ultimate success, but that one who enters it simply because he has no taste for other work, or because he thinks it is going to be an easy way to make a living, is likely to meet with disappointment. The failures in electrical engineering have been sufficiently numerous, but they have usually been cases of men who have had an imperfect preparation, have not been sufficiently determined to succeed, or who have been lacking in industry. Professor Crocker insists strongly upon the importance and necessity of a thorough preparation in a scientific school. It is, as he says, practically impossible, now that the art has become so thoroughly specialized, for a young man to acquire anything approximating a thorough knowledge of this most difficult subject while engaged in ordinary industrial employment. He emphasizes the fact that almost every man who has achieved success in the electrical field has been one of the quick-witted sort, such as are held by our Connecticut friends to be the possessors of that indescribable qualification known as "gumption." Moreover, there is required above all things, in dealing with electrical forces, a man who is careful, exact, and conscientious, in small things as well as great.

A DIRECTORY of the electrical industries recently issued exhibits in a most striking manner the rapid growth and extended development of this department of modern progress. It appears that more than 1850 of the cities and towns of the United States are now supplied with central-station electric plants, while the isolated plants number several thousands more, these being apparently in special favor in the textile industries; the street-railways using electric power now number more than 500; more than 50 different establishments, some of them very large ones, are engaged in the manufacture of dynamos; while the production of insulated wire and other miscellaneous supplies is enormous. It seems almost incredible that such an industry could practically have grown up as it has within the past fifteen years.

THE esthetic and decorative possibilities of the incandescent lamp are only just beginning to be appreciated. One of the most successful efforts in this direction, in a small way, is the lighting of the Long Island Sound steamer *Puritan*, in which the wreathing of the pillars with a spirally disposed and graceful trailing vine of hammered metal, of which the lamps form the blossoms, produces a peculiarly unique and pleasing effect. The most successful achievement thus far in this direction, however, is generally considered to be the interior of the church of St. Francis Xavier in New York city, in which the intricate renaissance decoration forms a most harmonious and admirable groundwork for the handiwork of the electrical artist, and one of which he has availed himself with the most picturesque and pleasing results.

ST. LOUIS boasts of one of the largest electric central stations in the world. It has 19 boilers, more than 5000 horse-power of engines and dynamos, and consumes nearly 100 tons of coal per day. The dynamos are located on the third floor of the main building, where no less than 75 of these machines may be seen at work in a single room. The switchboard is 60 feet long. The area of the district served from this station is 50 square miles, within which are 2100 municipal street lamps, supplied through 532 miles of wire. There

are, besides these, 1500 commercial lamps, with 240 miles of wire, making an aggregate of 3600 arc lamps. From the same station an area of 30 square miles is supplied by the alternating system with 20,000 incandescent lamps of 16 candle-power each, some of which are over 12 miles distant. Finally there are 20 miles of wire in the power circuits, to which thus far about 250 horse-power of small motors have been attached, working at a potential of 500 volts. All the wires are overhead.

IN a recent lecture Dr. Silvanus Thompson stated that none of the gas-meters now in use are capable of indicating one-tenth part as correctly as the electric meters now generally employed in connection with central lighting stations. American electric meters are acknowledged to be the most satisfactory of any, and are used in vast numbers in the European systems.

PROFESSOR E. P. ROBERTS, writing in the *Electrical World* on the designing of central stations for electrical distribution, says that there are few towns of any importance in which it is not now possible to install an electric plant which will pay a handsome return on the necessary investment, provided the plant is well planned and constructed, and efficiently operated. This has been rendered possible in part by the increased commercial efficiency of the apparatus now constructed by the leading manufacturers, and in part by the great decrease in price of apparatus within the past two or three years. Professor Roberts very justly criticises that species of economy which would not hesitate to pay an architect $5000 to design a $100,000 office building, even after the dimensions and general plan of the work have been determined upon, but which would begrudge an equivalent compensation to a competent electrical engineer to give advice respecting the location, dimensions, and arrangement of an electric plant costing an equal or even a much greater amount, which requires even a rarer quality of skill than much that is found in the profession of architecture. We entirely agree withhim in his conviction that a competent man, taking plenty of time to look over the ground and consider the various conditions, could design a station costing 10 per cent. less to operate than if the same person had been compelled to do the work hurriedly, or if it had been done by an incompetent man. Is it not therefore, he inquires, the part of wisdom to pay 10 per cent. of the cost of a station to have it properly designed, if a saving of 10 per cent. per annum in the expenses of operation may be thereby realized? It is notoriously true in every business of a technical character that good advice pays by far the largest percentage of any portion of the investment.

AN electrical encyclopedia has been projected by Mr. Park Benjamin, the publication of which will be undertaken by a prominent firm, provided sufficient encouragement is received from electrical engineers and others who would naturally be interested. Mr. Benjamin is undoubtedly well qualified to carry out the undertaking satisfactorily, and it is certain that a really good work of this kind is much needed.

THE Post-Office Department in Great Britain operates between 30 and 40 telephone-exchanges. The aggregate number of subscriber's telephones connected with the Post-Office exchanges throughout the kingdom is only 5382. Metallic return wires have been used in all cases, since the first introduction of the system. The National Telephone Company, a private corporation, has nearly 50,000 subscribers, and pays the government £45,000 per year in royalties.

A VERY useful application of the electric light to railway cars has recently been tested in Boston, with satisfactory results. A 16-candle incandescent lamp and reflector are located just under the sill of each passenger car close to the steps. When the train arrives at a station after dark, the brakeman turns on the light, and the passengers have a clear view of the steps and the platform in the vicinity. The cost of this improvement is trifling.

THE Boston *Transcript* says that the cry of "incendiary" has been provoked by the mysterious fires which have occurred in that city during the past few months, and expresses a suspicion that the name of this incendiary is "Electric Wire." We referred in these notes not long since to the action of certain ignorant and superstitious inhabitants of a remote southern State, fifty years ago, who destroyed hundreds of miles of telegraph lines because of a similar "suspicion" that this structure had been the cause of a succession of "mysterious" droughts which had destroyed their crops season after season, but we had heretofore given the Bostonians the credit of having risen somewhat above the intellectual level revealed by the *Transcript's* remark. Our own personal observations have been sufficient to convince us that the succession of disastrous conflagrations which have visited Boston during the past few years have been directly attributable, first to a vicious and utterly unsafe system of building, and second to inexcusable negligence in guarding, by efficient inspection, against unnecessary risks. Only a few weeks ago we noticed in a large seven-story building in the heart of the wholesale district a central elevator-shaft sheathed with pine, with windows opening into every story; the bottom of the shaft was utilized by the engineer of the building as a place of storage for oil, and plenty of inflammable rubbish was lying all about. A match or a spark dropped into this mess would set the whole building in a blaze in an instant. In our opinion a city where such practices are permitted need not charge its disasters to mysterious providences or to electric wires. The *Transcript's* reasoning appears to be something like this: "Electricity is something the exact nature of which is unknown; the origin of the mysterious fires in Boston is something the exact nature of which is unknown; hence as things which are equal to the same thing are equal to each other, the origin of the fires is necessarily electricity."

IT has long been known that lead suffers from corrosion when buried in certain kinds of earth. It has been discovered that the water supplied to the city of Glasgow, which contains free carbonic acid, and which has been found to attack lead, can be neutralized by chalk, so as to correct the evil. It has therefore been suggested that subterranean electric cables encased in lead tubes might with advantage be embedded in chalk. In this country a small mixture of tin has been found to answer an excellent purpose as a protection against corrosion.

A WRITER in *Industries* (London) makes some very pertinent observations in reference to the flood of books on electrical subjects which has been pouring from the press during the past few years. He says they come in for review in shoals, and, when he has collected a clothes-basket full, he is compelled to spend a miserable quarter of an hour in reviewing them. They all seem to be alike, not only in their letter-press, but in having the same wearisome illustrations of obsolete machines; the only difference is in the errors introduced. The really good book, written by a competent author, is a rarity. The most common variety is the scrap-book, made up of clippings from the technical press. Even this might be very useful if the compiler knew anything about his business and could give a collection of articles written by different specialists on some particular branch of the subject. But as a matter of fact, if he has fifty papers on the subject—say of dynamos—of which forty-nine are nonsense, he leaves out the good one because it looks too simple and contains no mathematical formulæ, and inserts the other forty-nine. He then strings the whole forty-nine theories into one chapter, if he is a Frenchman, and into one sentence if he is a German, in perfect unconsciousness that each one is absolutely contradictory of all the others. Then there is the "Electric-Light-Popularly-Explained" family of books. These are easy to write, being simply a rehash, warmed over, of similar preceding books, and may be illustrated with any old woodcuts available, or with electrotypes from dealer's catalogues. Then there is the electrical pocket-book, containing a vast

variety of useless misinformation which nobody could ever possibly want, and so on *ad infinitum*. The interesting fact remains that after all a very short list will cover all the really useful books relating to the science of electricity and its industrial application.

AT the recent Electric Light Convention, in St. Louis, Mr. L. B. Stillwell remarked that the central-station manager, who is buying energy in the form of coal and selling it in the form of light, and wasting it at every step of the process, is losing far more before the energy passes through the dynamo than afterwards. He estimates that, out of each 1000 horse-power bought in the form of coal, it is at present possible to sell not more than about 2.8 horse-power in the form of light. Some 930 horse-power is lost before reaching the dynamo, and the rest afterwards. It seems clear, therefore, that the problem of cheap electricity is in its final analysis a problem of thermodynamics.

THE everlasting question as to why the American electric-light managers will not use storage batteries came in for a share of the discussion at the Electric Light Convention. Professor George Forbes, of London, pointed out that the loss in using storage-batteries arose in part from the cost of installation, which is far in excess of the dynamos and machinery which they replace, the loss of energy in transformation within the batteries, amounting to 20 per cent. of all the coal used, and finally the heavy depreciation account, which is generally admitted to be not less than 12 per cent. per annum. It is pretty safe to say that, if the shrewd and sagacious men who are managing some of our largest central stations were able to see any economy in the use of storage-batteries, there would have been plenty of them in use here before this time.

IN a paper read at the Electric Light Convention Mr. L. B. Stillwell remarked that no perfectly general solution of the economics of central station operation can be worked out. Of 10,000 plants the fittest will survive and pay dividends, and central-station engineering will then consist of close study and careful analysis of the conditions and methods which have brought about the survival of these fittest installations.

MR. CALVERT TOWNLEY, in summing up an exhaustive discussion on the economics of the incandescent lamp, arrives at the conclusion that the profit falls off very rapidly for lamps either of too high or too low efficiency; in the first case, by the excessive cost of frequent renewals, and in the last by the excessive consumption of energy. This variation is more marked where current is dear and running expenses high. It is easily demonstrable that the long-lived inefficient lamp is a very expensive article to the consumer, and that too much weight has heretofore been given to the cost of lamp renewals, while not enough attention has been paid to the cost of energy. The fact is sometimes overlooked that there is nothing bought or sold in this world which does not represent energy, and that wasting energy is as bad as, nay, far worse than, merely wasting money. Money is a mere counter: energy is the thing that money stands for. The conclusions reached by Mr. Townley are gratifying in one respect at least, and that is that the possibility of increased profits in supplying light by electricity carries with it the implied possibility of reduced prices to the consumer, and correlatively, of a greatly extended use in comparison with other illuminants.

ONE of the subway commissioners of New York city is authority for the statement, made to a member of a Boston committee which has been seeking for light on the subject of placing electric wires under ground, that the arbitrary provisions of the New York law have worked great hardship to the electric companies. At least half the companies which were doing business at the time the subway commission was created are said to have been driven into bankruptcy. The commissioner said furthermore that the experience in New York had been that a great many consumers were

unable to pay the increased cost of service rendered necessary by the increased cost of subway construction, and that this discontinuance of service had proved fatal to many of the smaller companies. He mentioned one subway, several miles in length, which cost $500,000 to construct, in which, up to the present time, only three ducts had been rented.

A BILL is before the legislature of Massachusetts providing that the question of permitting electric railways to cross steam-railways at grade shall be placed under the jurisdiction of the State railroad commissioners. The proposed legislation is favored by the managers of the more important steam-railways of the State. The evil of grade crossings of this character is rapidly becoming a very serious one, and ought to be taken in hand by the authorities without loss of time. The manager of the Boston and Maine railroad says that there are already more than forty such crossings on his lines.

THE city of Boston paid last year for electric-lighting $216,445 against $193.702 for gas-lighting. The number of electric lights maintained by the city is 1547.

THE town of Peabody, Mass., is trying the experiment of municipal electric-lighting. The plant has now been in operation for some months, and the results of the first four months' operations have been made public. The total cost of plant to date is given as $48,176.92. There are 149 1200 candle-power arc lamps, connected with 40 miles of wire, lighting 23 miles of streets, and supplied by 4 dynamos having a capacity of 48 lamps each. The figures of cost of operation appear to have been honestly made, which is more than can be said of any other municipal plant within our knowledge. The operating expenses include interest on $50,000 at 4 per cent.; depreciation on $30,000 at 5 per cent.; taxes on $35,000 at $15, insurance $195, etc. The lamp-hours per year are computed at 3128, and the average cost for four months ending February 1, 1893, is given as 2.19 cents per hour, or $68.72 per annum.

BY an oversight which we regret, a paragraph appeared in these notes last month to the effect that the managers of the World's Fair had resolved to close the exhibition evenings. In November last it was authoritatively announced by the president of the executive department of the Exposition that it was not intended to close the Fair on all evenings, but merely to reserve the right to close on particular evenings, should circumstances render it advisable.

PHILADELPHIA has about 500 miles of street surface railway,—more than any other city in the world. The change from animal to electric power now going on will probably make a difference of some millions of dollars per year in the profits of the company which has succeeded in obtaining the franchise. It looks at the present time as if the whole system would be equipped and running before the horse-cars have disappeared from any of the streets of New York except Broadway and Third avenue.

THERE is an important street-railway junction in Boston, where there is a wonderful maze of trolley wires overhead, from which circumstance the locality has received among the employés the picturesque designation of "the rattlesnake." One day last month something gave way in the internal economy of the reptile. It was shortly after noon, and the whole transportation system of the West End Company was utterly paralyzed for two or three hours. It is stated that a large number of generators at the central power house were burned out. This, we believe, is the first time that such an accident has happened, and, as might have been expected, it created considerable consternation for a time.

THE General Electric Company have secured the temporary use of the Crescent Beach loop of the Boston & Maine Railroad near Lynn, Mass., for carrying out a series of experiments in reference to the application of electricity to ordinary railway train service.

MECHANICS

Conducted by Leicester Allen.

MECHANICAL resources have been very greatly extended during the past twenty-five years by the widening of the range of artificial temperatures attainable and maintainable. This range has been stretched out from both the positive and negative limits formerly reached. On the negative side temperatures of —210 C., equal to —334° F., are now reached and maintained for a considerable period by scientists in their experiments; and the examination of materials which at temperatures formerly practicable remained either gaseous or liquid, and which are either liquified or frozen at these low temperatures, seems likely to throw much new light upon the physical and chemical properties of materials in general.

Hydrogen, for instance, has long been suspected of possessing the character of a metal. Certainly there are certain metallurgic phenomena in which this gas plays a part that seem explicable only on this hypothesis. If, at the lower temperatures likely yet to be reached, this substance can ever be frozen, the question of its metallic character can probably be fully decided.

But it is the extension of the limit of artificial temperature on the positive side of the scale that has, as yet, increased mechanical resources, rather than the production of low temperatures. The temperatures of from 2500 to 3000° C.—the latter being equal to 5432° F.—are now as readily produced in electric furnaces as was half that temperature by means available twenty-five years ago. At the latter temperature most refractory substances, as for example lime, melt and run down like water. It is not beyond possible developments that nearly every substance known to man will, ere long, be brought into the class of practically fusible substances; that is to say, not merely reducible to a pasty plastic consistence like melted glass in glass-furnaces, but brought to a fluidity that will permit their being poured into molds, provided that any substance capable of standing up against heat of such intensity can be found for the molds.

AT a very interesting meeting of the New York Railroad Club held on February 16 at the rooms of the American Society of Mechanical Engineers, some things pertaining to automatic car-couplers now generally used on American railways were brought out in a topical discussion, in which many members of the club took part. It appears from this discussion that without a special appliance called the dead-block draw-heads are very liable to breakage. On the other hand, it has been asserted that the use of dead-blocks defeats the primary and most important purpose of automatic couplers, which was and is the protection of trainmen. The dead-blocks, receiving the shock when cars run together, protect the cars and reduce very much the breakage of draw-heads; but there appears to be a wide divergence of opinion as to whether they do or do not endanger the men. It came out in the remarks of Mr. C. A. Smith, who proposed the topic for discussion ("Should Dead-blocks be Applied to Freight-cars with Master Car-Builder's Couplers?"), that dead-blocks are in evil repute among many western railroad men, who have dubbed them "man-killers"; and even some of those who in the discussion advocated the use of dead-blocks admitted that they are dangerous if men are not careful. As Mr. Smith remarked, "men will not always be careful." Others regarded the dead-blocks as an element of safety not only to the cars, but to the men also. Mr. Rogers, who claimed to speak from extensive experience, said that, if he could have his

way, he "would want good solid dead-woods on all cars, whether it was the vertical-plane coupler or the old link-and-pin." President Blackall pointed out that "a great many men have been killed by the draw-head being knocked in and the man being caught between the cars." The discussion, on the whole, seemed to favor the use of dead-blocks both as a protection to trainmen and to cars. Mr. Medenhall raised a point not brought up by any other speaker present. He said: "The great strain that a freight car has to stand is the buffing strain. If there are no dead-blocks to take that strain, it must be taken by the automatic coupler, which is hung below your sills, and, as a consequence, you find that when the strain is severe it will break your stringers at the body bolster and every one of them will go. If dead-blocks are properly applied, you get your strain through your stringers and in many cases the body of your car will be saved, whereas, if the automatic coupler took the shock, the stringers would all be broken."

FROM a quarter that commands respect comes the following communication. Our correspondent prefers to conceal his real name by signing himself "Willett." His complaint will be echoed by many who have had similar experience:

Mechanical Editor ENGINEERING MAGAZINE:

Manufacturers of machinery would save themselves and the men placing their machines much delay and trouble, if they would get out a special drawing for each machine showing everything necessary for placing and connecting it up. Take for instance a steam engine. A drawing is at hand, sent by the engine builder to the engineer in charge of erecting an electric light plant. The size of the steam pipe is given, but the figures for the location of the nozzle are not. The same is true for the exhaust pipe. The foundation bolts are located in a sort of a way, but neither their size nor the thickness of the bed-plate lugs are given. Information is absolutely wanting about the fly-wheel and the number of revolutions. The drawing is not even to scale; just a few figures are scrawled upon the blue print with acid.

From that miserable sheet the engine maker expects the engineer to design everything, placing on foundation, piping up, and connecting to dynamos, so that the engine will run economically and evenly, and cast great credit on its builder; and so that it will lead to the sale of several more of the same style of engines for a similar class of work.

Of course, the engineer can and does get at all of these things, by an endless amount of telegraphing and writing; but how foolish this is, when a single blue print from a tracing, requiring not more than one or two hours' time of a cheap draughtsman, would tell the whole story.

This trouble is especially noticeable when a large plant is being erected, and when boiler makers, engine builders, pump makers, and all the rest of the manufacturers are equally negligent. WILLETT.

Chicago, February 21, 1893.

GOLD- and silver-mining on the Pacific slope have been carried on about fifty years; and the output of the mines during that period has been without precedent in modern history. But railroads, bridges, etc., though gold may pay for building, cannot be built *of* gold at a cost that will pay a reasonable profit on the investment. The time may even arrive in California when iron roads may cost more gold than is consistent with such prospective earnings and profits as may reasonably be hoped for. The possibility creates a desire for cheaper iron. The *Mining and Scientific Press*, in a recent issue, announced that the want of cheaper iron on the Pacific coast has become urgent, so much so that capitalists are endeavoring to find in deposits of iron ore and coal in California the possibility of establishing an iron industry near enough to the Pacific to save the freights on iron from eastern sources, it being the cost of transportation that renders iron dear in the markets of the Pacific coast. While eager to encourage this attempt, the paper quoted, in its discussion of the subject, does not appear over sanguine that it will succeed; nor does it make a showing of existing conditions that appears very tempting to eastern enterprise. There is plenty of good iron ore on the Pacific slope, and it is asserted that coal suitable for working the ore exists there also; but as the means for economically bringing the ore and coal together

do not exist, and to all appearance are not likely soon to exist, the ore might as well be in Maine as in California as regards its present availability. However, it appears that eastern capital is on the alert for any possible opening in iron manufacturing that may arise. The journal named says that "the Jones Creek iron mine, half a mile from Humboldt Bay, Humboldt County, has been leased to eastern parties, who intend to open and prospect the deposit. Should developments justify, a furnace will be put up."

There is, therefore, a big "if" in this operation. The proximity to Humboldt Bay is an element favorable to success, as, if a furnace should be there erected, fuel could be brought by sea to the works, and the shipment of the product could also be by sea. However, this is yet "all in the air," and it does not yet appear how the land of gold is going to get much cheaper iron than it is now getting, unless some way to cheapen transportation, not yet in sight, should solve the problem. It is probable that the crops grown on the fertile lands that skirt Humboldt Bay will long be a much greater source of wealth to California than any iron industry that can be developed in that beautiful region.

COMPRESSED air, as a means of transmitting power from prime motors, has been brought into prominent notice recently by its adoption in the shops of the Wuerpel Switch and Signal Company, at St. Louis, Mo. Illustrated descriptions of this plant, showing the arrangement of the prime motor, and the smaller compressed air engines with reference to the machines driven by the latter, have been printed in *The Iron Age* and other technical publications. The plant, as designed for the special work of this shop, is a decided innovation in shop equipment. The prime motor is a Norwalk air compressor of the compound type, and of 35 horsepower. This compressor forces air into a storage reservoir, from which the compressed air passes to the machine shop and pattern shop through underground pipes, and is there taken through overhead branch-pipes to descending pipes supplying Kriebel engines distributed in various parts of the works for driving different tools. There appears from the description to be seven of these engines for large tools and one 6x14 engine for small tools. This kind of power distribution does away with line shafting as effectually as electric transmission. About the economy of the system as yet nothing can be said that is based upon experimental data; and until these are forthcoming many will entertain doubts that it can compete with electric transmission in this respect, although all will at once concede the advantages of cleanliness and convenience. The exhaust of so many air-engines will, without doubt, assist much in cooling and ventilation in sultry summer weather. In winter, unless provision be made for conveying the air cooled by expansion to the exterior of the shops, these exhausts may add to the expense of warming. It is believed that this is the first instance on record where an entire manufacturing plant has been organized to distribute the power of a prime motor by compressed air, and to apply it where and when wanted, by the use of compressed air engines.

THE idea that small differences in thickness of metal make notable differences in the transmission of heat through it when large differences of temperature exist between hot liquids or gases on one side and the cooler gases or liquids on the other side is not sustained by the laws of transmission of heat by conduction. Such effects are notable only when small differences of temperature exist between the substance that imparts heat to the thin conductor and the body that receives heat from the other side. In the case of locomotives worked under high pressure, it is possible that the temperature of the gases of combustion may approach so nearly the temperature of the water in the boiler before reaching the smoke-stack as to make the greater thinness of the ends of the tubes remote from the fire-box somewhat more effective. Unless, however, any increased efficiency in heat transmission be experimentally shown in the use of these tubes over that found to exist in tubes of

the same thickness throughout and having also the same mean thickness, it may reasonably be doubted that the alleged superior efficiency exists, except in the case that some other assignable cause for increased efficiency appears plausible.

THE enormous mechanical energy in waves rolling in over a shelving beach has never yet attracted the attention it merits as a possible source of mechanical power. Now that electrical transmission of power has been carried to such a degree of practicability that a distance of from ten to twenty miles from the source of power is no bar to the utilization of water power at points within these or even greater limits, it appears that the same amount of science and skill that has been applied to the solution of the problem of mechanical flight should be able to give to the world the wave mill. A moment's reflection will convince any mechanical mind that wave-power enough, and a great deal more than enough, daily goes to waste on Rockaway beach, to supply New York, Brooklyn, and Jersey City, with the heat, light, and mechanical propulsion required by these cities for all purposes. A nearer but lesser source of wave-power exists at the Coney Island beaches.

ASSUMING that the problem of transmission of power is solved, as it is practically, though we may reasonably look for a large progress in this branch of electric engineering, the first step towards the solution of the problem of the construction of a practicable wave-mill is to find means for converting motion of very variable amplitude into uniform motion in prime motors.

The second step will be to provide means whereby an exceedingly variable supply of power may be stored for use, so that a uniform supply may be distributed to points where it is needed for useful work. In the carrying out of any such project very large wastes at the point of supply will be of little moment, since we should be drawing from a source that is at present all waste. When it is further considered that the origin of waves in bodies of water may be traced directly through their immediate cause, the winds, to solar heat which causes the winds, it is also made evident that we should be drawing power from a primary source that may be considered as infinite and inexhaustible when compared with the needs of mankind. Economy in storing, transmitting, and applying the power, rather than the hoarding of such a permanent and generous supply, will demand attention.

Professor Thurston has given us, in a late number of THE ENGINEERING MAGAZINE, a graphic picture of the part played by wind-power in the history of advancing civilization. The introduction of wave-mills, if successfully accomplished, would more profoundly influence the progress of our race than any other human invention has ever done, with the single exception of the steam-engine.

A FIRE-BOX seam-protector devised by Mr. W. J. Davis, general foreman of the Foxbury shops on the Pittsburgh and Western railway, commends itself to sound mechanical judgment as a useful innovation. The object of the device is to keep rivets cool by the passage of air over them from below. It is extremely simple both in construction and application, being merely a bar of 3″x1⅛″ iron bent to correspond with the contour of the interior of the firebox, at the place where it is desired to protect a row of rivets, and held in place by a single ¾″ stud inserted at a point about two inches below the top of the protector. The device is stated to have been first tried on an old locomotive, and, having proved entirely successful in stopping leaks, it has since been applied to other old fire-boxes. The protector is made to cover only the leaky part of the seam. It burns out in about two months. The heat force exerted upon it would, in its absence, be expended upon the seam. Leaky seams, thus protected, are said to have run six weeks without any leakage. Why would this not be good practice for new locomotives also? *The Railroad Gazette*, in its issue of February 3, gave a diagram illustrating this simple, practical device, which seems, however, sufficiently com-

prehensible both in principle and construction without such aid.

EVERY mechanic should fully realize that no reliance can be placed on the measurements of sizes or distances indicated on any caliper or gage used in any place whatever, where the precision is required to be absolute to standard rather than comparative to the means employed to indicate such standard. Such variations in ordinary machine-shops may be as much as .0005 of the size indicated, and this variation may be proved and should be tested by every practical man. Suppose that a vernier gage having twelve inches capacity be held at its widest opening between two parallel pieces of equal length in a vise, and a rod about one-quarter inch in diameter be fitted to it so that it just fills to touch the gage and no more, the rod being freely handled to warm it; then, if the vernier gage be removed from the vise and the rod be substituted for it between the parallel pieces, the gage being still freely handled to warm it, the length of the rod will be found to indicate much shorter, perhaps by one-hundredth of an inch.

UPON the value of training students in technical and trade schools for mechanical pursuits in advance of that sterner and more rigid training received in shops, there has been much diversity of opinion and much argument, the prevalent opinion being that such schools are very useful in certain directions, while in others they are greatly deficient. In an inaugural address delivered by Professor R. H. Smith at the opening meeting of the Mason College Engineering Society at Birmingham, England, this gentleman expressed the opinion that "the most difficult and tedious part of technical training" is the cultivation of what he styled "reliable instinctive faculties"; that in this "the technical schools can, at least, make a good beginning, and that herein really good practical results can be produced." His opinion of what a mere school training can *not* do is equally well put:

> What a mere school training can *not* do is to impart that habitual caution and careful accuracy which comes only from a sense of responsibility. The scholar pays his fee and thinks he does his whole duty if he submissively accepts the lesson for which he has paid the fee; he cares little whether he makes a blunder in executing the exercises which he has given him, knowing that the evil results of his blunder are for the most part confined to himself, and that there are no ulterior consequences to himself of any very grave or dreadful sort,—none such as would in the other place [work-shop] cause the foreman suddenly to blaze forth in language quite unfit to be heard within the sacred precincts of the college. Practically the worst that he can fear, as the result of his error, is the waste of so much material; and he has rather a habit of thinking that because he has paid a fee he has the right to waste so much material per day, the proper amount being settled by himself within his own private conscience.

A remedy for this is suggested by Professor Smith,—to wit, that students shall only be employed on real work, and held to account strictly for any carelessness in the performance of any part of work contributing to a general result, the same as though he were a shop apprentice. All who have thought much upon this subject will be likely to appreciate both the defect and the remedy proposed for it. The trouble will be in the practical application of the remedy.

The atmosphere of a school is totally unlike that of a workshop, as is tacitly admitted in Prof. Smith's allusion to the language a foreman would be apt to use to a delinquent apprentice. Students are the recipients neither of wages nor of the brow-beating that fall to the lot of apprentices in shops, and it may well be questioned by shrewd observers of the social ethics of shops whether the guying and ridicule to which heedless and slovenly youths are subjected as a penalty for their blunders is not the very best discipline for the cure of such faults.

ARCHITECTURE.

Conducted by Barr Ferree.

THERE seems to be no diminution in those relics of uncivilized times,—architectural competitions. Every year some important mercantile building is decided by this cumbrous, expensive, and unnecessary method, which is as sensible as if a sick man were to send for a half-dozen doctors and promise to engage the one that would effect the speediest cure. How long this state of things is to continue it is idle to predict, but, being an unavoidable evil, it is clearly right to make it as little an evil as possible and to eliminate from it every possible suspicion of unfairness. Architectural competitions, unfortunately, are looked upon in so many quarters as perfectly natural and proper things that the methods of conducting them are very well known, very well understood, and, so far as the architect is concerned, very well systematized. A well-drawn competition program is a thoughtful document, embodying a multitude of details and requiring a wide acquaintance not only with the practice of architecture, but with the entire history of architectural methods. It is a document that cannot be drawn by every architectural practitioner, and, as might be expected in this era of specialism, we are gradually producing a small school of competition-program makers, who, if this system is to be continued, must, before long, exercise an influence on current architecture quite out of proportion to their merits. It is hard for the most conscientious program-maker not to infuse his personality into it, to indicate his own personal inclinations as to style and treatment, to tell the architect, so far as he dares, how to treat the problem it is only his business to indicate in the most summary fashion. Much of this is unavoidable, but the influence of this hidden and powerful force in current architecture is not to be despised. In the limited competitions which are now the fashion, the most careful scrutiny is exercised as to the architects who shall be invited to compete for it. Their merits and demerits, their advantages and failings, their good work and bad, are all passed in review and the very best selected. Yet who examines the program-maker, who questions his authority or his competency, studies his prejudices or makes allowances for his idiosyncrasies? He needs looking after as sharply as the architect. He may be, if he chooses, a most dangerous man.

The professional program-maker is a natural product of the competition system. Under our present architectural fashions he is more likely to be a teacher of architecture in an architectural school than a practising architect. For some reasons such a person possesses many advantages for the work. He is not distracted by the labors of actual practice; he has time to give to study for which the busy man of affairs can devote no moments. Years of exercise in criticisms of youthful drawings have trained his mind in critical methods, even though the material on which it has thriven has not been of the healthiest and most invigorating kind. All of these are distinct advantages, and, coupled with the fact that he has probably had much experience in these things,—else how could he be a professional program-maker?—make him a very proper person for this sort of work. But he has his disadvantages, as have most people and much architecture. The teaching of architecture, as the teaching of any subject, tends to keep the teacher's mind in a single rut. He views things from the academic standpoint, and in this country knows no architecture save that taught in the Rue Bonaparte. In other words, the architectural teachers of this country have so positively made up their minds that the system of the Ecole des Beaux-Arts is the only one to be employed in instructing young archi-

tects that nothing else is considered necessary for their training. Instructors in construction must, perforce, keep pace with the gigantic constructive strides American architecture is now making, but the teacher of the art of architecture, as the more ornamental side is often wrongly called, and who is most likely to be the professional program-maker, knows no architecture save that of Paris and its world-famous school. A person so trained is not in the least fitted to draw up a program for a competition for a business building, for example. What have orders, and columns, and friezes to do with a business building? One has only to look at those examples in which they occur to find an answer. The Professorial Professional Program-Producer—to give him a stated title—is out of touch with much modern work. Living in a single style, he sees solutions in it only, and his program is drawn up accordingly. An architect finding hints of the classic strongly stated in the program necessarily imagines that he must follow them. And thus the Professorial Professional Program-Producer helps along his own school by forcing the use of his style, whether it be really suited to the problem in hand or not. The retarding influence he can exert on the progress of American architecture may not always be recognized, but it is nevertheless a fact. The creators of competitions should examine his merits as well as those of the architects they invite before putting his work out upon a long-suffering though perhaps indifferent world.

If the antecedents of the professional program-maker need to be looked into in every well-ordered competition, the antecedents of the jury should be not less carefully studied. The deciding of competitions, as well as the drawing up of their programs, is rapidly falling into the hands of the professors of architecture. Architects, in active practice, are either taking part in the competition, or do not wish to give the time and thought necessary to the judging of a series of architectural designs. Besides, the mental agony incurred in looking at atrocious designs is likely to interfere with the work of an artistic architect for some weeks to come. And so, the architects not being available, the jury plums fall to the professors. And people more unsuited to such work it would be hard to find. Professors, like other folk, have their prejudices and failings, their inclinations and preferences. They like one style, abominate another, and look with indifference upon a third. The style they like is doubtless the only one they know, since even a professor of architecture cannot know everything; certainly it is the one they are apt to judge by, because it is the best. Here comes a new element for the architect. He not only has a program drawn up by a biassed hand, but he knows that, if he wishes to gain a certain competition, he must follow the inclinations and prejudices of his jury. An architectural jury, unlike one in a court in law, does not judge by facts, but by prejudices. If an architect knows its members to be classicists, he knows as well as he knows anything that, if he sends in anything but a classical design, he will have his trouble for his pains. He might, if he has a strongly-marked individuality, work out a thoroughly practical design in some other style, but he wants that building, and bends his mind to an uncongenial task, and then wonders why he did not get the prize. Thus the architectural professor retains his grip upon current architecture, though its methods and necessities may be quite foreign to his style of thought and art. Both the Professorial Juryman and the Professorial Professional Program-Producer are legitimate products of the competition system; yet both are fundamentally opposed to the true progress of architecture. To a very large extent they are a neglected element in current architecture, but they are getting in their innings with the wisdom of the proverbial early bird. A true appreciation of their real nature must help to destroy much of the present false confidence in the unquestioned merits of competitions, as it will likewise help to make clear their inherent unfairness. Meanwhile the Program-Producer and the Jurymen should be carefully selected in every case. They cannot, if architecture is to live, be permitted to become a class.

ABOMINABLE as architectural competitions necessarily are, some good words may be spoken for the bill passed by the late congress permitting limited competitions for public buildings. If there has been one phase of American architecture more atrocious than another, it surely has been its official side. Americans do not naturally do foolish things, but they clearly exceeded all previous records when they evolved an architectural system whereby a single office, and nominally a single architect, should be responsible for the huge number of government buildings yearly erected in this country,—a number now estimated at about 300. And in order to make things as bad as possible,—as if this in itself were not sufficiently preposterous, —all of this was to be done by an architect holding office for not more than four years, and often for less, and, as likely as not, as incompetent to undertake work on this gigantic scale as he was to earn the meager salary of the post by private practice. It is no wonder that the architects of this country have been protesting for years against the horrors of this situation, and it is no credit to the intelligence of our national legislators that years have been necessary to bring about a reform. The new law contains many imperfections and is not at all what it should be, but it is a move in the right direction. The secretary of the treasury is now authorized to institute a competition limited to five architects for any public building at his discretion. This is the substance of the law. It is not mandatory, it need not be applied in every instance, and only the successful architect is entitled to compensation for his plans, which are to be executed under the supervision of the supervising architect of the treasury. Insufficient as the law is, it must work many important and long needed reforms. Whether under it our official architecture will take a fresh lease of life and thrive and flourish in a way long unknown to it may be doubted. But then this art could not, by any possibility, be worse than it is, and there is every reason to believe that the present entering wedge will prepare the way for further efforts and more successful results in the near future. For several years the chief business of the meetings of the American Institute of Architects has been the discussion of such a law as this, and the taking of measures to secure its enactment. The present legislation is largely due to the activity of that body, but its occupation is not yet gone. There is much to be done yet for the furthering of American official architecture, and of American architecture in general, before the Institute can regard its chief mission as finished.

ONE of the most notable changes in current architecture is the transformation which is taking place in the color of our buildings. It was only a few years ago that our chief cities were characterized by a dullness of color scarcely supportable; now they fairly blaze in a multitude of shades which is the more remarkable since it has always been considered that polychromatic architecture is quite impossible in the rainy, damp, changeable climate in which the people of the seaboard American cities see fit to live and thrive. We have by no means obtained a polychromatic architecture, as it is understood under the brilliant skies of southern Europe, but our cities are exhibiting a diversity of color, and a variety of tint that is positively delightful after our interminable red bricks and brown stones. Much of this variety is caused by the yellow brick which has become so fashionable of late, the use of which is growing, if anything, a little too promiscuous. But it affords a grateful change and enables the architect to obtain results quite impossible with the older and more common red. Red, as a city color, is rapidly moving from the walls to the roofs, red tiles being now as much in favor for a roof covering as red bricks were once for walls. That the possibilities of red are not yet exhausted—rather that they are not yet understood—is evident from the gorgeous coat of red paint that has recently been applied to an iron building of the old type that directly overlooks the City Hall Park in New York. Such a deep, rich color was never seen on a building before, and the effect of a six-story struc-

ture painted in this ravishing shade from top to bottom, only relieved by a few advertising signs uniformly painted in plain gold, is positively startling. From an ordinary unattractive structure this building has become one of the most conspicuous in New York, and it is well worth a trip to lower Broadway to see it. It offers possibilities in the coloring of buildings hitherto undreamed of, and it would not be surprising if the success of this transformation should popularize the horrible old-style iron structure that no one has known what to do with. Chicago has its Golden Doorway, but New York has its Red Building, and for startlingness of effect the latter city has nothing to be ashamed of.

IT is difficult to understand why Professor N. S. Shaler should work the readers of the *North American Review* up to a horrifying fear of the dangers high buildings run from earthquakes, only to assure them, in his conclusion, that the danger is not very great or likely to do any of us harm. There is absolutely no limit to the what-may-happens, and the possibilities of earthquakes on the Atlantic coast are not too remote to render it foolish to take them into account. Any sort of catastrophe may happen in a great city, and a heavy shock of earthquake would unquestionably do a vast deal of damage not only among high buildings but among low ones. The human mind, however, is not given to estimating at their real value remote probabilities. One need not trump up an earthquake to find danger to human life and limb in many an apparently well-built and outwardly good building, which may be known to be unsafe, but which no one hesitates to enter. And then when one finds, after all, that the likelihood of an appalling catastrophe from earthquake is very small, one cannot but wonder why a stir should have been made about it. It is to be regretted that Professor Shaler, in composing his terrifying paper, should not have consulted an architect or an engineer. Had he done so, he would have escaped making several errors of his own and would have made a much more valuable contribution to high-building literature than he has done. Thus he speaks of buildings intended to last through centuries. Costly as our high buildings are, it is not to be supposed they are intended to last for that length of time. Their duration may naturally be longer than that of the low buildings they replace, but it is not at all improbable that new conditions of life and business will arise which will render their present form quite unsuited to a more advanced state. It is surprising, also, that so keen an observer as Professor Shaler should refer to the present limited use of steel in building. One need only look over any great city and see the gigantic steel skeletons rising from every street to realize how large a part this material takes in current building methods. And this omission on the Professor's part is the more to be regretted since he looks upon the increased use of steel in building as an additional safeguard against earthquakes.

Mr. BERG'S book on buildings and structures of American railroads* is a notable production in many ways. Not only is it the first considerable book of its kind on the subject, but it is thoroughly complete, dealing in the most detailed manner, and with the amplest illustrations and examples, with all sorts and kinds of railroad structures, from watchmen's shanties to the terminal railroad stations of great cities. It is this which gives the book its real value and which will make it, for many years to come, the best authority on the subject. The larger part of the work is devoted to what may, for want of a better term, be called the mechanical part of railroad building, to the study of the structures used in the actual workings of a railroad, and which, though often devoid of architectural treatment, are, from the railroad man's standpoint, more important than the costly depots and stations of large cities. Much of this material is, of course, without architectural interest, but it is a very necessary

**Buildings and Structures of American Railroads.* A Reference Book for Railroad Managers, Superintendents, Master Mechanics, Engineers, Architects, and Students. By Walter G. Berg, C. E. New York: John Wiley & Son. 1893.

part of railroad architecture, and Mr. Berg follows it through the smallest detail in the most conscientious manner. The examples given are numerous and selected from all the railroads in the country, so that the reader has here, in convenient form, representative types of the best railroad construction. Aiming as he does to represent chiefly railroad construction, the author does not undertake to illustrate the architectural possibilities of these buildings. Yet in glancing over his pages one may obtain a very fair notion of the architectural status of railroad buildings in this country. As a whole it is not satisfactory. Many of the smaller buildings, those of wood and in which cheapness is naturally the first consideration, actually lose by attempts at decoration. Probably no class of wooden structures have been so neglected in this country as railroad stations and similar buildings, though many changes for the better have been introduced in the stone and brick buildings now generally erected. The architect, in fact, has little opportunity to display his ability in such buildings, and it is only in the more considerable edifices that railroad architecture attempts to become artistic. Mr. Berg's book is a monument of painstaking labor, and may be most cordially commended to all directly concerned with the topics of which it treats, while the general student of architecture may learn much of interest and of value from it. It is so thoroughly good that the author will pardon our regret that the names of his sketches, of which there are seven hundred, were not placed underneath them. The designation "perspective," "ground-plan," etc., is in every case intelligible without a printed legend to that effect. The name of the building illustrated in the perspective or plan, as the case might be, would have been of assistance to the reader.

LAST month we had occasion to refer to the fiftieth anniversary of our venerable London contemporary, *The Builder*. We have now to extend our congratulations to a much younger contemporary, and this time an American, *The Inland Architect*, of Chicago, which has just celebrated its tenth anniversary. This lively, wide-awake, and admirably edited periodical is one of the few indispensable periodicals to the American architect, supposing, of course, that he is sufficiently interested in affairs to wish to keep abreast of architectural progress in the west. It is a clean, wholesome paper, breathing the ceaseless activity of the west in every line, and reflecting the most admirable features of its architectural thought. It is a pleasure not only to be familiar with its text and its plates, but to be able to congratulate it on reaching the end of its first decade. Not the least of the merits of *The Inland Architect* is the support and encouragement it gives to western architects to write for its pages. We have more than once had occasion, in this place, to refer to the lack of the literary habit among American architects. This reproach cannot lie at the door of our breezy western contemporary. While it might, perhaps, be an exaggeration to say that one of its missions is the formation of a school of literary architectural writers in the west, it has, by making copious use of the literary products of western architects, gone as far as an independent journal could go that was not wholly committed to such a policy. Its readers may, therefore, always count on some fresh, interesting, and valuable contributions, which, with its judicious and thoughtful editorials, make it one of the very best papers of its kind in this country. If it has a fault, it is that it only comes to hand once a month instead of once a week. We extend it hearty congratulations on reaching the present period in its career, and trust we may be able to renew our felicitations at many subsequent such occasions.

INDUSTRIAL CHEMISTRY.

Conducted by Dr. R. A. Witthaus.

THE hygiene of building materials is a study but little known in this country, although in Europe it has attracted considerable attention. Dr. Serafini, assistant at the Institute for Experimental Hygiene in Rome, has recently published the results of a series of experiments on this subject, an account of which may be found in a recent number of *Good Health*.

The porosity of various materials was determined as follows: Small pieces were dried at a temperature above 100° and then placed in hot distilled water in such a manner as to drive out completely the air contained within the pores. When the mass was saturated, the surface was dried with bibulous paper and the exact volume determined according to the principle of Archimedes. The surface was then again dried and the mass weighed, after which it was thoroughly dessicated by heating to above the boiling-point of water, and a second weight taken. The difference in weight indicates the amount of water absorbed by the pores, and the relative volume of water to that of the whole mass was thus obtained. Figures expressing the total volume of the pores as compared with the volume of the mass were as follows: Lime rock, 44.62; red brick made by machinery, 32.79; red brick made by hand, 36.77; mortar from an old wall, 33.88; travertine, 4.44; and marble, 0.25.

The permeability to air was also determined, and a table is given. It was found that one square meter of a brick wall two feet thick, one-fifth of which was composed of mortar, transmitted in one hour's time, with a pressure equal to that of a water column of two inches, 600 liters of air, or about twenty-two cubic feet. It has been falsely assumed that, owing to the porosity of ordinary building material, artificial ventilation is of small consequence. The ridiculousness of this position is at once apparent when we compute that an atmospheric pressure equivalent to a water column two inches high is only produced by wind traveling at the rate of forty-five miles per hour, while the pressure of a light breeze is 500 times less than that required in the above experiment to produce twenty-two cubic feet an hour. It will be remembered that not less than 2000 cubic feet of air per hour are required for each person. The amount of air passing through a wall in a given time is diminished by increased thickness, but not in direct proportion. A five-fold increase in the thickness of a wall diminished the air transmitted only one-half, while increasing the thickness of a wall twenty-five fold only reduced the volume of air to one-fourth. A third series of experiments was conducted by Dr. Serafini to determine the best conducting property of different materials, and a table of the results are given, cork being taken as unity.

A more interesting study was that of the relation of the various materials to microbes. Lime and mortar, it was found, never contain microbes, and when the latter were incorporated with the former in laboratory experiments, they soon disappeared. Old walls, however, contain microbes even to their centers, as was demonstrated by Dr. Sanfelice in regard to the walls of the hospital San Gallicano. It was shown by the experiments that the microbes of the air pass through building materials only with great difficulty, but when suspended in water they readily find their way into the interior of the mass. "In one case germs were found to have penetrated four inches into a brick after it had been in contact with the culture for six weeks. The *bacillus prodigiosus* penetrated a block of limestone to a depth of four inches in five weeks, without pressure, and to more than

half that depth in the space of two weeks. The ready penetration of limestone, brick, and similar material by germs renders important the adoption of means to prevent the saturation of walls from contaminated soils. The author draws the conclusion from his various experiments that the lateral walls of buildings should be made impermeable to air, not only to prevent the penetration of the walls by microbes, but to allow for frequent washing without saturating the walls by moisture.

PASSING on to a material of construction treated from another point of view, we have the admirable papers on Portland cement and Portland cement concrete by Mr. Bamber, Mr. Carey, and Mr. W. Smith presented to the British Institution of Civil Engineers. It is pointed out in the paper by Mr. Bamber that the usual method of determining the completeness of burning, namely, by weight per bushel, is fallacious, and that the specific gravity is a better guide. He states that a good new cement should have a specific gravity of 3.1 to 3.15, and that, if it fall below 2.9, the cement has either been improperly burned or has afterwards deteriorated by exposure. In the taking of the specific gravity, he advises water rather than turpentine, which is generally used, on account of the sensitiveness of the latter to the temperature. The practice of aërating cement is deprecated. Interesting experiments upon the proper proportion of water to use in mixing concrete are described. Blocks composed of four parts of shingle, two of sand, and one of cement were used, and several sets more made in duplicate with varying proportions of water. The first were mixed with as much water as the cement would take up, or about 10 pounds for each block; the second with 7½ pounds of water; and the third with 5 pounds. After standing for a fortnight one of these sets was placed on a sea-wall for twelve months, where it was exposed to tide action, and the other was similarly exposed to the action of fresh water. Upon examination at the end of the period named it was found that the one with 10 pounds of water was hard, sound, and dry throughout; the one with 7½ pounds of water was dry at the center, but had been penetrated to a depth of three inches; while the one with 5 pounds of water was wet through, much of the lime had been removed by the sea-water, and the block was weak. Other experiments proved that, with the decrease in the amount of water used, the bulk, and consequently the porosity, was increased. The author concludes that it is necessary, in order to secure sound concrete, to have it thoroughly wet, that it may be non-porous and impermeable to the action of the water when placed in position.

In the paper by Mr. Cary, on "The Inspection of Portland Cement for Public Works," is shown the fallacy of the once universal requirement that not more than 10 per cent. of the cement should be left on a sieve with 2500 meshes per square inch. In reality it is only the floury cement that has any cohesive properties, and the residue left on a sieve with 32,257 meshes per square inch has practically no cementitious value. The effect of fine grinding is thus shown: A standard sample was prepared, giving, with 9 per cent. of residue on a sieve of 2500 meshes, a tensile strength of 220 pounds per square inch. With the residue above removed 304 pounds per square inch were obtained, while with the residue on a sieve of 32,257 mesh removed the tensile strength was 360 pounds per square inch.

In opposition to Mr. Bamber, Mr. Cary deems the aëration of cement desirable, to remove the baneful effects of free lime; and, in view of the change that cement often suffers on a long voyage, he suggests that it be exported in clinkers to be ground at its destination. Mr. Cary also insists upon the necessity of determining the specific gravity and gives as the minimum a gravity of 3.1. With respect to testing he is in favor of the one-inch by one-inch briquette, and prefers hand-trowelling to the Arnold apparatus, because of the great facility in judging the quality by manipulation. Exposure to frost was found to delay the increase in strength of cement, though the final strength is the same.

Mr. W. Smith, in his paper on "The Influence of Sea Water upon Portland Ce-

ment, Mortar, and Concrete," shows that where exposed to water, and particularly in the case of sea-water, it is of greatest importance that the concrete structure be impervious. A series of experiments was performed, and the conclusions were that (1) the cement must be finely ground; (2) the cement should not be present in smaller proportion than 1 to 6 of sand and stones; and (3) the concrete must have sufficient time to set before the application of the pressure. Mr. Smith shows the futility of trusting to a film of calcium carbonate for securing impermeability, and also criticises the use of a covering of Portland-cement mortar from the same purpose. He concluded that the only certain way is to build the entire mass impermeable.

WE take the following note from the *Engineering and Mining Journal:* "In this country a good deal of difficulty is experienced in testing cement because of the liability of the briquettes breaking through the head, instead of at the small cross-section. This irregular fracture can in most cases be attributed to the fact that the jaws grip the briquette along a line, instead of the surface of the jar being in contact with the briquette over a considerable surface. In Europe a different form of jaw is employed, and, according to the research of a French Government commission of engineers, there are in consequence fewer cases of irregular fracture. In the report they say that these better results are due both to the form of the briquette, which is molded with a groove in its center, and to the form of the grip, which, instead of being sharply convex and thus affording only a small surface of contact, has a large radius of curvature at the point of contact." It is of extreme importance that physical tests, often imperfect at the best, should be conducted with most scrupulous care and attention to details in order that the results may have even an approximate value. Hence it is to be advised that our American engineers should avail themselves of the hints thrown out by France in this matter of cement-testing. As a rule the American takes the lead in such matters, his native ingenuity in the adoption of "machines" removing from him all "personal equation" and the accompanying liability to fall into error. There are many instances, however, where old and imperfect methods may be found, and there is, as there always must be, room for vast improvement, especially in this line of physical testing.

IN a paper read by Mr. H. S. Poole before the Mining Society of Nova Scotia an account is given of the experience in that country with the flameless explosives "roburite" and "acadine." The former was introduced from England in 1890, but previous to that date gunpowder was the only explosive known, and owing to the fiery nature of many of the mines it had become necessary in some instances to close down. The principal experience so far has been with roburite, which has given satisfaction, though at first there were many complaints. The miners complained of missed shots, of shots that did but half the work expected of them, and of charges that did not explode. The trouble was found in the failure to follow the instructions, and in tamping the charge as they had been accustomed to tamp gunpowder. The cartridges were exposed to damp and were otherwise maltreated. Naturally they refused to do their work, but now that the new material is better understood, it is steadily growing in favor, and so far about 7300 pounds have been used. In only a few instances have flames been observed, and a possible cause in these may have been in a short circuit of naked exploding wires. The tendency in the beginning was to use too much of the roburite, but now its strength is understood to be weight for weight 2½ times greater than gunpowder, and its quantity is regulated accordingly. Among the disadvantages may be named that common to all compounds containing ammonium nitrate,—that is, of absorbing moisture on exposure to the atmosphere, being thereby first weakened and then rendered useless. The cartridges are rendered waterproof by dipping in paraffin, but as an additional caution it is well to store them in a magazine where the air is kept dry.

Acadine, a mixture of ammonium nitrate with nitroglycerin, is manufactured by the Acadia Powder Co., of Waverly, N. S. On account of the possible decomposition of such mixtures with the formation of acid and possible consequent explosion, their manufacture is prohibited in England, but no such misfortune has occurred in Nova Scotia, where, however, the precaution is taken of using the material as soon after making as is possible. Acadine has several important advantages over roburite, among which are the following: It is cheaper and requires a less expensive detonator; hard tamping does not affect the explosive power, and consequently, when a charge fails to explode on the detonation of the cap, a second primer with a fresh cap may be used. This is not so with roburite, which becomes consolidated to the extent of defying explosion. In only one case has light been observed, during an experience with 6400 pounds of the material. The strength of acadine is 50 per cent. greater than gunpowder.

IT has been a frequent practice to ventilate a cargo of coal with the view of removing the inflammable gases therefrom. That this in itself is an introduction of a source of danger is made clear by Professor Clowers, of Nottingham. From an account of his observations in the *American Gas Light Journal* we abstract the following:

Four colliers were loaded with coal from the same seam and by means of the same tips. Three were ventilated and the fourth was not; the former were consumed by fire before reaching Aden, while the latter arrived at Bombay in safety. It was evident that the ventilation of the coal had supplied just that air necessary for its combustion when heated which was absent in the case of the unventilated coal. Coal which has been heated in the air and has begun to cool again is safe from further heating; hence storing coal in the air for a sufficient time before loading is calculated to insure the safety of the cargo. The following conclusions were reached: First, the danger of spontaneous firing of coal in large lumps is very slight; it is much greater with smaller coal, and greater still with dust. The increase of danger is due to the larger extent of surface exposed to the air in proportion to the mass of the coal. Second, air-dried coal which contains more than 3 per cent. of moisture is dangerous; if it contains less, the danger diminishes. The moisture contained is a measure of the absorbent power of the coal for air, and the more absorbent the coal, the more dangerous. Third, the danger is somewhat increased by the presence of pyrites, in large quantity. Fourth, newly won coal should be shielded from the air as much as possible, to prevent the chance of rapid heating, and for the same reason it is best not to stack it in large heaps, since these retain the heat. Ventilation of the coal often adds greatly to the risk of spontaneous firing. Fifth, all external sources of heat, such as steam-pipes, boilers, and hot flues in the neighborhood of the coal, add very greatly to the risk. Spontaneous heating becomes vastly more rapid when it is assisted from without.

THE removal of sulfur from purified gas has ever been an important and difficult operation in the manufacture of illuminating gas, and there is probably no gas man in the country that has not, at one time or another, been called upon to "explain" to the consumers why it is their gas "smells so." This bad-smelling gas certainly is most offensive, but, when the manager promises the irate customer that the trouble will be remedied, he is often secretly perplexed and worried to know how to do it. In view of the importance of this subject, the paper read by Mr. Goodno before a recent meeting of the New England Association of Gas Engineers is of extreme interest. Mr. Goodno gives the public the benefit of his observations and experiments upon the removal of sulfur, and an additional value is given to the paper by the able discussion which followed.

In the fall of 1890, when using a large percentage of Glace Bay coal and purifying about 1500 cubic feet per bushel of freshly prepared home-made sponge, many complaints were received of the sulfur in the gas. The trouble was remedied by the

use of lime in about equal quantities with the sponge. The lime, rapidly fouling by the formation of sulfid of lime, retained the carbon bi-sulfid of the gas. At this time a cargo of Pennsylvania coal was received, and used for some months. When the Glace Bay coal was again reached, the former trouble was expected, but did not put in appearance, the same sponge being in use as before. The improved condition was now looked for in the old sponge, which by this time carried a high percentage of free sulfur; and, as one of the few solvents of sulfur at ordinary temperatures is carbon bi-sulfid, it would be reasonable to suppose that the converse is true and that the free sulfur of the sponge had taken up the carbon bi-sulfid of the gas. For the purpose of experimenting upon the removal of the bi-sulfid an apparatus was set up for burning 8.10 cubic feet of gas per hour in the presence of ammonium gas and condensing the products of combustion by suitable cooling arrangements. The sulfur was thus obtained as ammonium sulfate. Purified gas from the holder gave at 60° temp. 11.8 grains per 100 cubic feet, while the same gas after passing at 50° temp. through old sponge heavily charged with sulfur gave only 5.4 grains per 100 cubic feet. The same gas with the same treatment except that the temp. was 60° gave 4.4 grains. These results will suffice to show the manner of experimenting and some of the results obtained. At a higher temperature the sulfur in the gas again increased, owing probably to the driving over of the carbon bi-sulfid, which is of course very volatile. The same gas as above, passed through a purifier filled with flowers of sulfur moistened with steam, gave 3.2 grains per 100 cubic feet, and in all probability this small amount consists of other compounds of sulfur than the bi-sulfid. That old oxid heavily charged with sulfur and thoroughly revivified will answer as well as fresh lime in removing the bi-sulfid seems to be theoretically true and borne out in practice, for in comparing the State inspector's reports it will be seen that upon turning on a fresh box of old sponge the gas tests lower in sulfur. Mr. Goodno suggests that an extra purifier placed after the ordinary ones and filled with the oldest available sponge carrying a high percentage of free sulfur would effect a permanent improvement in the quality of the gas and prove a safeguard against crossing the 20-grain limit. Such an additional purifier would need changing only at long intervals, and the expense would be small. A discussion followed, and many interesting points of experience were brought to light.

VARIOUS processes, electrical and other, have been suggested and tried for the disposal of sewage, or for the nullification of its poison, which is the same thing. A process invented by Mr. William Webster has been tried in England, and that of M. Hermite has been in operation for some years at Rouen, with highly promising results. The method in vogue at this latter place—namely, the electrolysis of the sewage direct after the addition of common salt or chlorid of iron—would hardly be practicable in a city like Paris with its enormous output of sewage daily, but a modification could be used and the electrolyzed solution added to the sewage. This application of electrolytic disinfection becomes especially possible wherever sea-water is at hand, as for instance on shipboard or at the seacoast towns, so often starting points of infectious diseases.

MINING AND METALLURGY.

Conducted by Albert Williams, Jr.

MISREPRESENTATION in a prospectus sometimes subjects the company fathering it to certain after inconveniences, at least in English law. Not that a serious result is certain to follow; but it may. Indeed, if there were any certitude or even probability that false or exaggerated statements in a prospectus would react upon the utterers, the extraordinary literature of the incipient English mining corporations would have been considerably abridged. However, a case has recently come up in the English courts, the decision in which may rather astonish most readers, for the offence was by no means of an especially heinous order, but one which seems trivial in the light of what has been published officially by mining corporations there and elsewhere. In the case referred to, the plaintiff had applied for and had been allotted a certain number of shares in a new company, on which he had paid certain sums, and he petitioned to have the register of shareholders rectified by having his name removed, and to have the money so paid refunded to him. The ground of the application was that the prospectus contained misrepresentations, the particular one proved, and upon which the judge held that the applicant was entitled to the relief asked for, being a statement that the "promoter" would provide the preliminary expenses of floating the company, whereas in fact in the contract between him and the company it was stipulated that such expenses should be repaid him, which they were. Plaintiff claimed that what induced him to invest was the apparent good faith shown by the "promoter."

Another case which came up before the same court shows, however, that a shareholder, if he has ground for complaint as to matters contained in the prospectus which induces him to subscribe for shares, must not let the grass grow under his feet. In this case the plaintiff awaited the issue of a suit by another shareholder, and after the latter had been successful he delayed a month longer before taking action. The court held this delay to be unreasonable and the right to relief forfeited.

Commenting upon these two cases, "A Barrister," writing in the London *Mining Journal*, gravely warns directors of new companies that it will be well "to see that the statements contained in their prospectuses are accurately phrased," and advises them, "if they have any doubt as to the meaning likely to be placed by an intending subscriber for shares on any particular sentence," to consult their lawyer—and hedge.

The innocence of the British investor and the peculiar methods of the British "promoter" are subjects of constant wonderment in the United States, but so far as crookedness goes it's the old story of the mote and the beam. At this very time wildcat mining shares are being floated upon American small investors on the strength of prospectuses and reports which under the first ruling just cited would, in the English courts, and under similar circumstances, entitle the victims to recover the amount of their investments. A little more law of that kind would have a salutary effect everywhere. If it did not deter those who are pecuniarily irresponsible from pushing fraudulent schemes, it might at least cause sponsors of new companies to be cautious in putting forth reckless and over-colored statements about the properties whose shares are offered to the public.

BASIC steel is reported as making decided progress abroad as a material for engineering construction, such as bridges. In Germany and France it is even being specified as the material to be used in such work, and *Iron* [London] states that in

the former country experiments are being carried out to prove that it is equally, if not better, adapted for constructive purposes and even for shipbuilding than Bessemer or open-hearth steel. It is further reported that in France the process is so successful that basic metal can now be produced cheaper than manufactured iron, and promises to take the leading position there. In England large orders have been placed recently for basic steel in plates, bars, channels, and angles for bridges and similar work, though the output is still behind that of Germany. In the United States there are special reasons why the growth of the basic process has been checked, but the production promises to be considerably increased by the operations of a new company in the South. The prejudice against the metal seems to be disappearing, and the process promises to do much toward developing the large deposits of phosphatic ores, otherwise unavailable.

AT a recent meeting of a foreign engineering society, in the course of a discussion of papers upon lead-smelting for the precious metals, one of the speakers expressed a doubt whether in American practice over 92 per cent. was saved of the contents of the ores treated. Such a statement of course argues total ignorance of the subject. It is a sufficient refutation to say that the custom smelters, in buying ores, pay on the basis of 95 per cent. of their tenor in silver and lead; while for gold, if the ore contains over one-twentieth of an ounce per ton, they pay for the total contents. They pay for silver and lead the full rates established by the New York quotations of the day, and for gold either $19 or $20 an ounce. The smelters have to stand transportation expenses on the crude lead bullion to the refinery or market, usually at a long distance, also cost of refining, commissions, etc. Further, the smelters pay cash for ores on receipt, but as the lots bought may be carried for stock in the bins or in the ore beds for some time, they lose the interest on the value of their purchases, often for many months. The system of buying ores is complicated by the varying smelting charge, discrimination against silica, zinc, or other undesirable elements, and allowance for iron and other fluxing constituents. But the fact that the basis of the business is as just explained shows that the percentages saved in smelting must be high. Competition in the ore market has rendered close figuring a necessity, but the smelters certainly do not conduct operations at a loss. Whether there is a profit or a loss on a particular lot of ore bought cannot always be told. The kinds and proportions of the ores in stock influence the selection of new material. Each lot loses its identity in the smelting mixture, so that what its individual results may be is not known. In the long run the system pursued is undeniably profitable, though precise calculations are difficult even to the managers, owing to the complexity of the business. It is estimated that about 10 per cent. of the lead, carrying a less proportion of silver, passes out of the stock as fume and flue dust. Of this over one-half is ultimately recovered in the annual clean-up. One of the great smelting-works has more than a mile of flues and dust chambers, and a main chimney 350 feet high. With a plant like this the losses in fume and dust are brought very low, while modern methods keep down the loss in slags, besides which there is a partial retreatment of the slag shells. As to the gold, the smelters invariably overrun the assay figures; that is, they get out apparently more gold than is charged into the furnaces as ore. This is because all silver and lead ores carry traces of gold, which, if too small to appear in the assay reports, still count up in the aggregate when concentrated in the bullion and refined, while much of the flux carries other small quantities, and also because, as stated, the smelters do not pay for less than one-twentieth of an ounce (say $1) per ton. The loss of gold from volatilization is slight. What passes into the flues and dust chambers is mostly carried off mechanically with the other matters. If exceedingly refined assays were made of the most minute quantities of the precious metals entering into the furnace charge,

and if there were an absolute clean-up of everything, the campaign would be found to give a better showing than a recovery of 95 per cent. on each of the three metals, silver, lead and gold, in the regular practice at our largest custom smelting-works. The managers know pretty closely what they are doing, but not quite. The public naturally knows less.

IT is sometimes argued that the invention of the safety-lamp has done more harm than good. It has reduced the number of colliery explosions; but on the other hand it must be admitted that explosions, when they do occur, are of far greater gravity than they might have been had no safety-lamps been in use. This is readily understood when it is remembered that the safety-lamp encourages working in gaseous mines which, without it, would have had to be abandoned, and that confidence in it begets carelessness, which sooner or later by some trifling accident brings about disaster. Collieries are also worked on a much larger scale than at the beginning of the century; the workings are vastly more extensive, and the number of men exposed in any given instance has been correspondingly increased. Yet it would be taking a very short-sighted view of the conditions to condemn the lamp on that account. M. Le Chatelier, whose admirable work has been previously quoted in these pages, rightly says on this head that it is sufficient, in order to prove the value of the invention, to compare the number of deaths caused by fire-damp with the quantity of coal extracted, which has increased with marked rapidity,—tenfold indeed,—while, happily, accidents have by no means increased in the same proportion. The truth is that the safety-lamp is only one factor of safety, and must not be counted on to do more than should fairly be expected of it. So far as its own proper function extends, it is a great help; but it is not everything. It is not possible to prevent the emission of fire-damp or to neutralize it; nor can dangerous accumulations be always guarded against; nor is there any certainty that causes of ignition can be wholly suppressed. In short, as M. Le Chatelier concludes, it must, as a rule, be acknowledged that it is quite impossible to entirely do away with any of the above-mentioned causes of accident, and we must be content to reduce their frequency to a minimum. He adds: "Moreover, the simultaneous attenuation of the different causes permits of obtaining a degree of security in itself considerable, almost absolute; it is, in fact, the case that, if each of the causes of accident occurs by itself with tolerable rarity, the probability of their simultaneous occurrence, which is indispensable for bringing about an accident, will become infinitely minute." This he illustrates by supposing the frequency of fire-damp accumulations "equivalent to that during one whole day out of a thousand working days; and also supposing the frequency of causes of ignition to be equivalent to the use of naked lights during one whole day out of a thousand working days. Then the probability of simultaneous occurence of accumulations and exposure to ignition will be as 1 : 1,000,000,—that is to say, an accident would occur on an average once in every three thousand years, which may be regarded as practically absolute security. If, on the other hand, account be taken only of the causes of ignition, without diminishing the causes of accumulation,—that is to say, if regular working be carried on in fire-damp (as has been too long the practice in collieries), it will no longer be every 3000 years that an accident will happen, but every three years." Which would mean that the colliery would have to be abandoned. M. Le Chatelier's assumed figures are fictitious, but they bring out the case very clearly. The evident moral is—*ventilation*, with every secondary precaution besides.

IT is believed that the production of platinum is closely regulated by the demand and the price. In 1891 the output from the placers in the Urals was 136,220 ounces of crude platinum, about 80 per cent. fine. This was valued at about $5 per ounce, crude. The production in 1891 increased 30 per cent. on that of the preceding year, being stimulated by the marked advance in price, which had

reached $16 per ounce for the pure metal. Since then the price, which had been artificially upheld, has declined to its normal rate of $8 or $9 per ounce, though the consumption of the metal for the leading wires of incandescent lamps is on the increase, while its use for crucibles and other chemical apparatus and for jewelry remains the same. The small quantity (500 to 600 ounces) of crude platinum sand annually obtained in connection with gold placer mining in the United States would doubtless be increased if more attention were given the matter, while some new Canadian localities promise well. A small supply comes also from Brazil and from the Cordilleras of South America.

IMPORTANT deposits of bauxite have been discovered in Saline and Pulaski counties, Arkansas. This mineral is used in the manufacture of aluminum, as a refractory material, and in making alum and aluminate of soda. Professor J. C. Branner, State geologist, reports that the beds vary from a few feet to over 40 feet in thickness. Its identity and value were not recognized until lately in Arkansas, where it had been prospected as an iron ore, and used for building roads, without suspicion of its real nature. As Professor Branner says, bauxite is not a common mineral in any part of the world, and as it has a spongy earthy appearance, and is very light, there is nothing about it to attract the attention, and this is probably the reason it has been so long over-looked. The French bauxite mines are the principal source of this mineral. In the United States it appears to be of rare occurrence, so far as known, though there is a bed of it in Georgia.

GRADUATES from the technical schools at first find themselves rather at a loss when brought to face the great number of samples to be assayed daily in a large smelting or other metallurgical establishment. At the school laboratories there is always plenty of time, but little room; and the methods taught there are right in principle, but dilatory. In practical work things are different, and both methods and apparatus may seem strange to the novice. Here the assayer has to keep up with the regular routine of the establishment,—so many samples to dispose of daily, so many in a batch, and the reports to be turned in at stated hours, with occasional extra pressure in emergencies. If he runs behind and is overweighted by the rush of business, he is likely to get rattled and make breaks. After a while, however, he picks up wrinkles which enable him to get through the regular tale with more comfort. At every large works short cuts and special appliances have been adopted or invented to meet the peculiar exigencies and handle great numbers of assays rapidly without detracting from such precision as may be necessary. Some are pretty generally known in the profession, others are almost private property, though not kept so for the same reason as trade secrets. All these things are not taught in the schools or described in the text-books. Every young assayer has to be coached by his more experienced associates, or find out for himself. Another thing he has to learn, not often inculcated in his preliminary training, is to discriminate between matters requiring minute exactness and those which can be treated more roughly, and to divide his effort accordingly. There is a great deal of floating unpublished knowledge about assaying which the professors and the text-book writers seem to be unconscious of. It is a pity, for it places the student at a disadvantage in the outset. If every assayer who has originated or learned new time-saving or labor-saving devices that are proved to work well in practice would make them known through the technical press or the transactions of the societies, eventually the schools and the books might get hold of them, and there would be less lost motion.

INVESTORS in gold- and silver-mining property have a weakness for taking up too much territory,—*i. e.*, more than can be well handled under one management. One claim of full size, 1500 feet long, is large enough to contain a big mine; and two continuous claims give as much ground as can be advantageously worked from a

single shaft sunk near their junction. One mine at a time is enough, and is worth any number of undeveloped prospects. It is also better policy to concentrate effort on the most promising ground, and not dissipate it by scratching about tentatively. Yet Eastern and foreign companies usually buy a whole group of locations, and in their prospectuses and reports make a parade of owning so many distinct "mines." There is, however, a very good reason why, in many situations, the owners of a valuable mine should wish to acquire title to all the adjacent claims; and that is for mere protection against the uncertainties of litigation under our dubious mining laws. Conflicts over titles are always to be expected where a property is worth anything. To guard against them a certain extravagance in purchasing territory is warranted, and may be considered prudent. But this is something apart from mining policy proper.

ACCORDING to the *Colliery Guardian*, English coal-miners work on the average only about 40 hours per week, the range being from 32.87 to 44.9 in different districts. This estimate is surprisingly low, lower in fact than those for any other European coal-mining country, or for the United States, where in the leading districts the weekly range is from 48 to 52 hours. In the principal German coal-fields the average per week is 48 hours; in the Belgian collieries, 54 to 56; and in the principal French coal-fields, 50. When the British labor commission was in session last year, considerable antagonism to an eight-hour law was evinced by many of the coal-miners, who considered that, if such a limit were imposed, it would involve, if not as an express enactment, at any rate as an implied corollary, that they should not work less than eight hours daily. As in all similar cases, it seems to be impossible to fix by legislation any time limit which shall be satisfactory to all—still less to bring the several elements of length of working day, wages, occupation for the greatest number of men, output, consumption and price of product, into consistent harmony and reconcile them for the best of all concerned, by any artificial restrictions. The natural adjustment is the safest, and practically it always prevails in the long run.

COMPOUND or bi-metallic plates of steel and copper are being made in Germany as a material for various utensils. Sheet steel is used, having a coating of sheet copper either on the inside or on both sides.

A PLANT for the retreatment of copper tailings by the sulphuric-acid leaching process is to be established by the Arizona Copper Co., at Clifton, A. T., to work over the tailings from its concentrating mill. This process of extracting copper has been for a long time successfully employed, though on a small scale, at the Lyon mill, at Dayton, Nev., where the bluestone (copper sulphate) produced found a local market in the amalgamating mills of the Comstock lode.

BY means of electric welding it is now possible to produce forged steel projectiles rapidly and economically. A hollow steel bloom is cast and rolled out to a thick-walled tube of the approximate size of the finished shell. This is cut into suitable lengths, and the head and base, formed in dies, are then welded on. Very little machinery is necessary. A high-carbon steel head can be welded to a cheaper lower-grade material. These electric-welded shells are being made by the American Projectile Co., at Lynn, Mass.

THE cause of unusually rapid rusting of some rail-bedplates has been attributed to a high percentage of silica and sulphur in the original iron, from investigations recently made upon material supplied to the Austrian railways.

THE total production of pig iron in 1892 was 9,157,000 gross tons, against 8,279,870 tons in 1891, and 9,202,703 tons in 1890. The production in 1892 was only 45,703 tons less than in 1890, in which year our maximum production was attained. The production in the first half of 1892 was much larger than the last half.

THE TECHNICAL INDEX.

A CATALOGUE OF LEADING ARTICLES PUBLISHED CURRENTLY IN THE TECHNICAL JOURNALS OF THE UNITED STATES AND GREAT BRITAIN.

THIS publication has been aptly described as "the greatest step that has been taken in recent years towards systematizing work" for the engineer, the architect, the electrician, the railway manager, and the business man. The list of publications regularly indexed will show that it covers a world-wide range of the best technical literature, and all the articles are so conveniently classified under general headings that within a few minutes an active man can learn of everything that has been published during the month in relation to his special lines of investigation. In short, it is to the practical man just what Poole's celebrated index to periodicals has long been to the literary worker, but with this essential difference,—namely, that in addition to indicating *just where* leading articles have been published, *we undertake to supply copies of the articles themselves.* The unparalleled convenience and economy of this double service can readily be appreciated.

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[In the body of the index only the initials of the journals quoted are given, and these can be readily identified by the following list of periodicals. Other abbreviations are: Ill=illustrated. w=words.]

THE AMERICAN PRESS.

A.....Arena. *m.* $5 per year. Boston.
AA.....American Architect. *w.* $8. Boston.
An A A..Annals of Am. Academy of Political and Social Science. *b-m.* $6. Philadelphia.
A An.... American Analyst. *f.* $1 per year. N. Y.
A Ar.....American Artisan. *w.* $2. Chicago.
A & B....Architecture and Building. *w.* $6. N. Y.
A B M...Architect, Builder, and Manufacturer. *m.* $1.50. Kansas City, Mo.
A CJ....Am. Chemical Journal. *b-m.* $4. Baltimore.
A D..... American Druggist. *m.* $1.50. New York.
A E .....Architectural Era. *m.* $3. N. Y.
A G .....Am. Geologist. *m.* $3.50. Minneapolis.
A G L J...Am. Gas Light Journal. *w.* $3. New York.
A H.....Annals of Hygiene. *m.* $2 per year. Phila.
A J Phar.Am. Journal of Pharmacy. *m.* $3. Phila.
A J R A..Journal of Railway Appliances. *m.* $2 per year. New York.
A M.....American Machinist. *w.* $3. New York.
A M & I W.American Manufacturer and Iron World. *w.* $4 per year. Pittsburg.
Am A....American Agriculturist. *m.* $1.50. N.Y.
Am G....American Gardening. *m.* $1. N. Y.
A M M...American Mechanics. *m.* $1. Minneapolis.
Am M....American Miller. *m.* $2. Chicago.
Am S....American Shipbuilder. *w.* $2. N. Y.
A & N J..Army and Navy Journal. *w.* $6. New York.
A & N R..Army and Navy Register. *w.* $3 per year. Washington.
A R.....Architectural Record. *q.* $1. New York.
A Rev....Architectural Review. *s-q.* $5. Boston.
A S .....Age of Steel. *w.* $3. St. Louis.
At M.....Atlantic Monthly. *m.* $4 per year. Boston.
B B.....Brick Builder. *m.* $2.50. Boston.
B C.....Boston Commonwealth. *w.* $2.50.
B & D....The Builder and Decorator. *m.* $2. Minneapolis.
B G S .. Bulletin of the American Geographical Society. *q* $5. N. Y.
B I S.....Bulletin of American Iron and Steel Association. *w.* $4. Phila.
B J C....Boston Journal of Commerce. *w.* $3 per year. Boston.
B P .....Bulletin of Pharmacy. *m.* $1. Detroit.
B & W...Builder and Woodworker. *m.* $1. N. Y.
C.....Compass. *m.* $1 per year. New York.
C A.....Calif. Architect. *m.* $3. San Francisco.
Can A ...Canadian Architect. *m.* $2. Toronto.
C & B... Carpentry and Building. *m.* $1. New York.
C B T....Builder and Trader. *w.* $2. Chicago.
C E .....Colliery Engineer. *m.* $2. Scranton, Pa.
C E N....Canadian Electrical News. *m.* $1 per year. Toronto.
Ch.....Chautauquan. *m.* $2. Meadville, Pa.
C M.....Century Magazine. *m.* $4 per year. N. Y.
Cos.....Cosmopolitan. *m.* $3 per year. New York.
D E.....Domestic Engineering. *m.* $1. Chicago.
D J .....Drainage Journal. *m.* $1. Indianapolis.
D Jour. .Druggists' Journal. *m.* $1. Chicago.
E A.....Electrical Age. *w.* $3 per year. New York.
E E N Y..Electrical Engineer. *w.* $3 per year. N. Y.
E I.....Electrical Industries. *m.* $3. Chicago.
E M.....Engineering Mechanics. *m.* $2. Phila.
E Mag ...Engineering Magazine. *m.* $3. New York.
E M J....Engineering and Mining Journal. *w.* $4 per year. New York.
E N.....Engineering News. *w.* $5 per year. N. Y.
Eng.....Engineer. *s-m.* $2 per year. New York.
E N Y....Electricity. *w.* $2.50. N. Y.
EP D....Electrical Progress and Development. $2. Boston.
E R.....Engineering Record. *w.* $5. N. Y.
E & R ...Electricity and Railroading. *m.* $1 per year. Boston.
E R N Y..Electrical Review. *w.* $3 per year. N. Y.
E W.....Electrical World. *w.* $3 per year. N. Y.
F .....Forum. *m.* $5 per year. New York.
F D.....The Foundry. *m.* $1. Detroit.
F M.....Farm Machinery. *m.* $1. St. Louis.
F W .....Fire and Water. *w.* $3 per year. N. Y.
G & F....Garden and Forest. *w* $4 per year. N.Y.
G G M...Goldthwaite's Geographical Magazine. *m.* $2 per year. N. Y.
G R.....Good Roads. *m.* $2 per year. N. Y.
I A.....Inland Architect. *m.* $5 per year. Chicago.
I Age....Inventive Age. *s-m.* $1. Washington.
Ir Age..Iron Age *w.* $4.50. N. Y.
I R W...India Rubber World. *m.* $3 per year. N. Y
I S F....Industry. *m.* $2 per year. San Francisco.
I T R....Iron Trade Review. *w.* $3. Cleveland.
J A .....Journal of Architecture. *m.* $2. Phila.
J A C S..Journal of the American Chemical Society. *m.* $5 per year. N. Y.
J A E S..Journal of the Association of Engineering Societies. *m.* $3 per year, Chicago.

J F I.....Journal of the Franklin Institute. *m.* $5 per year. Philadelphia.
J M S I..Journal of the Military Service Institution. *b-m.* $4 per year. Governor's Island, N. Y. H.
J N E W.Journal of the N. E. Waterworks Association. *q.* $2. New London, Conn.
J P E.....Journal of Political Economy. *q.* $3. Chicago.
J U S A..Journal of the United States Artillery. *q.* $2.50. Fort Monroe, Va.
L E.....Locomotive Engineering. *m.* $2. N. Y.
L F M...Locomotive Firemen's Magazine. *m.* $1. Terre Haute, Ind.
L M.....Leather Manufacturer. *m.* $3. N. Y.
L Mag...Lippincott's Magazine. *m.* $3. Phila.
L P.....Louisiana Planter. *w.* $3. New Orleans.
M & B...Manufacturer and Builder. *m.* $1.50. N. Y.
M & El...Mechanic and Electrician. *w.* $2 per year. St. Louis.
Met W...Metal Worker. *w.* $2 per year. N. Y.
M G.....Manufacturer's Gazette. *w.* $2.50. Boston.
Min.....Minerals. *m.* $1 per year. N. Y.
M I T....Mining Industry and Tradesman. *w.* $3 per year. Denver.
M N.....Mechanical News. *s-m.* $1.50. New York.
M R.....Manufacturer's Record. *w.* $4. Baltimore.
M R C...Marine Review. *w.* $2. Cleveland, O.
M Rec....The Marine Record. *w.* $2. Cleveland.
M S P....Mining and Scientific Press. *w.* $3 per year. San Francisco, Cal.
M S R....Mining and Scientific Review. *w.* $2 per year. Denver.
N A R...North American Review. *m.* $5. N. Y.
N B .....National Builder. *m.* $3. Chicago.
N B D. .Northwestern Builder and Decorator. *m.* $2. Minneapolis.
N C B...National Car Builder. *m.* $2. N. Y.
N M ...Northwestern Mechanic. *m.* $1. Minneapolis.
N W.....Northwestern Architect. *m.* $3. Minneapolis.
O M.....Overland Monthly. *m.* $3 per year. San Francisco.
O P D R..Oil, Paint and Drug Reporter. *w.* $6. N.Y.
P.....Paving and Municipal Engineering. *m.* $1 per year. Indianapolis.
P A.....Progressive Age. *s-m.* $3. New York.
P D.. ...Painting and Decorating. *m.* $1. Phila.
P E. .....Practical Electricity. *f.* $2 per year. Boston.
P E C P.Proceedings of the Engineers' Club. *q.* $2. Phila.
P Era... Pharmaceutical Era. *s-m.* $2. Detroit.
P L.....Pacific Lumberman, Contractor, and Electrician. *w.* $3. San Francisco.
P M. . .Paper Mill. *w.* $3. N. Y.
P R.....Pharmaceutical Record. *s-m.* $1.50. N. Y.
P S.....Power-Steam. *m.* $1 per year. N. Y.
P S M....Popular Science Monthly. *m.* $5. N. Y.
P S N....Popular Science News. *m.* $1. Boston.
R A.....Railway Age. *w.* $4 per year. Chicago.
R A E J..Railroad and Engineering Journal. *m.* $3 per year. New York.
R C J....Railroad Car Journal. *m.* $1 per year. N. Y.
R G.....Railroad Gazette. *w.* $4.20 per year. N. Y.
R M.....Roller Mill. *m.* $2. Buffalo, N. Y.
R M M..Railway Master Mechanic. *m.* $1. Chicago.
R of R...Review of Reviews. *m.* $2.50. N. Y.
R P.....Registered Pharmacist. *w.* $1. Chicago.
R R.....Railway Review. *w.* $4 per year. Chicago.
R S P....Rudder, Sail and Paddle. *m.* $2. N. Y.
R T ....Rose Technic. *m.* $1. Terre Haute, Ind.
R & T...Roofer and Tinner. *m.* $1 per year. N. Y.
R'y N....Railway News. *m.* $2. N. Y.
S... .....Stone. *m.* $2 per year. Indianapolis, In d.
S A.....Southern Architect. *m.* $1. Atlanta.
San.....Sanitarian. *m.* $4 per year. Brooklyn.
Sc.....Science. *w.* $3.50 per year. New York.
Sc A ....Scientific American. *w.* $3. N. Y.
Sc A S ...Scientific American Supplement. *w.* $5. N. Y.
Sc M....Scribner's Magazine. *m.* $3. N. Y.
S E .....Stationary Engineer. *w.* $2. Chicago.
Sea.....Seaboard. *w.* $2 per year. N. Y.
S Ec.....Social Economist. *m.* $2. New York.
S Era... Sanitary Era. *m.* $1 per year. N. Y.
S J E....Sibley Journal of Engineering. *m.* $2. Ithaca, N. Y.
S M.....Scientific Machinist. *m.* $1.50. Cleveland, O.
So L.....Southern Lumberman. *s-m.* $2. Nashville, Tenn.
S M Q. . .School of Mines Quarterly. $2. N. Y.
S P.....Sanitary Plumber. *s-m.* $1. N. Y.
S R G....Street Railway Gazette. *w.* $3. Chicago.
S R J....Street Railway Journal. *m.* $4. New York.
S R N. ..Street Railway News. *w.* $3. N. Y.
S R R....Street Railway Review. *m.* $2. Chicago.
S V.....Safety Valve. *m.* $1 per year. N. Y.
T... ....Tradesman. *s-m.* $2. Chattanooga, Tenn.
T A I E E.Transactions American Institute of Electrical Engineers. *m.* $5 per year. N. Y.
T C E....Transactions American Society of Civil Engineers. *m.* $10. N. Y.
T Q.....Technology Quarterly. $3. Boston.
W E. ...Western Electrician. *w.* $3. Chicago.
W F E E. World's Fair Electrical Engineering. *m.* $3. Chicago.

THE FOREIGN PRESS.

A L.....The Architect. *w.* 26*s.* London.
A M S.. Australian Mining Standard. *w.* 30*s.* per year, postpaid. Sydney, Australia.
B A... .The British Architect. *w.* 23*s.* 8*d.* London.
C G.... ..Colliery Guardian. *w.* 27*s.* 6*d.* per year, post-paid. London.
C R.....Contemporary Review. *m.* $4.50 per year, New York. London.
C T J....Chemical Trade Journal. *w.* 12*s.* 6*d.* per year, post-paid. Manchester, Eng.
D. ..... Discovery. *w.* 8*s.* 8*d.*, post-paid. London.
E.....Engineering. *w.* 36*s.*, post-paid. London.
E E L....Electrical Engineer. *w.* 17*s.* 4*d.* per year, post-paid. London.
E G.....Engineers' Gazette. *m.* 4*s.*, post-paid. London.
E L.....Electricity. *w.* 6*s.* 6*d.*, post-paid. London.
El. .....Electrician. *w.* 24*s.* post-paid. London.
Eng L... Engineer. *w.* 36*s.*, post-paid. London.
E P.....Electrical Plant. *m.* 6*s.* per year, post-paid. London.
E R L....Electrical Review. *w.* 21*s.* 8*d.* per year, post-paid. London.
F R.....Fortnightly Review. *m.* $4.50 per year. New York. London.
G E M...Gas Engineers' Magazine. *m.* 6*s.* 6*d.* per year, post-paid. Birmingham, Eng.
G W.....Gas World. *w.* 13*s.*, post-paid. London.
I.....Iron. *w.* 30*s.* per year, post-paid. London.
I & S....Iron and Steel Trades' Journal. *w.* 25*s.*, post-paid. London.
I C B....Illustrated Carpenter and Builder. *w.* 8*s.* 8*d.* per year, post-paid. London.
I C T....Iron and Coal Trades' Review. *w.* 30*s.* 4*d.*, post-paid. London.
I E.....Indian Engineering. *w.* Rs. 18 per year, postage extra. Calcutta.
I Eng....Indian Engineer. *w.* Rs. 15 per year, postage extra. Calcutta.
I L.....Industries. *w.* 32*s.*, post-paid. London.
Inv.....Invention. *w.* 28*s.*, post-paid. London.
J G L....Journal of Gas Lighting. London.
J S A....Journal of the Society of Arts. *w.* London.
K.....Knowledge. *m.* 6*s.*, post-paid. London.
M.....Machinery. *m.* 9*s.*, post-paid. London.
M E.....Marine Engineer. *m.* 7*s.* 6*d.* per year, post-paid. London.
M E & E J.Manufacturers' Engineering and Export Journal. *m.* London.
Min W..The Mining World. *w.* 21*s.* post ex. London.
M W.....Mechanical World. *w.* 8*s.* 8*d.* per year, post-paid. London.
N..... Nature. *w.* $7, post-paid. London.
N C.....Nineteenth Century. *m.* $4.50 per year. New York. London.
P Eng...Practical Engineer. *w.* 10*s.* per year, post-paid. London.
Pl D .....Plumber and Decorator. *m.* 6*s.* 6*d.*, post-paid. London.
Rev R...Review of Reviews. *m.* $2.50. New York. London.
R N.....Railway News. London.
R R L...The Railway Review. *w.* London.
R W.....Railway World. *m.* $3, post-paid, London.
S L.....Steamship. *m.* Leith, Scotland.
S R.....Sanitary Record. *m.* London.
W R.....Westminster Review. *m.* $4.50 per year. N. Y. London.

ARCHITECTURE.

10537. New Office Buildings in Chicago. Ill. (E N–Feb. 16) 2400 w.

10542. A Notable Concrete Building. Ill. (E N–Feb. 16) 700 w.

10558. St. Louis Requirements for Slow Combustion Buildings (E R–Feb. 18.) 1400 w.

*10683. Slate and Slate Quarrying. Ill. George H. Harris (S–Feb.) 2700 w.

*10684. Tennessee Marble and the Congressional Library Building (S–Feb.) 2500 w.

*10687. Stone and Its Uses H. F. Perry (S–Feb.) 2000 w.

*10711. Tests of Building Stones. Ill. (Can A–Feb.) 1800 w.

*10730. Berlin. Ill. Friedrich Spielhagen (Cos–March.) 6000 w.

10757. The Saxon Church at Bradford-on-Avon. Ill. (A A–Feb. 18.) 2000 w.

10759. The Caisson Foundations of the Manhattan Life Insurance Building.—Letters from Charles Sooysmith, and Kimball & Thompson (A A–Feb. 18.) 1250 w.

10786. A Vicar's Views of Church Restoration. T. Perkins (B A–Feb. 17.) 950 w.

*10810. The Value of Criticism. C. J. Tait (A L–Feb. 17.) 6000 w.

*10811. The Theory of Storiation in Art. Hugh Stannus (A L–Feb. 17.) 8000 w.

10814. Town Gates in Southern Germany. Ill. (A A–Feb. 25.) 2:00 w.

10815. The March of Ancona. M. W. (A A–Feb. 25.) 1800 w.

†10853. High Buildings and Earthquakes. N. S. Shaler (N A R–March.) 3000 w.

10918. Glass Houses. Ill. (Am G–Feb.) 5000 w.

*10928. Whither Is Our Architecture Tending? C. W. Hopkins (B & D–Feb.) 2600 w.

10932. Decoration of Ceilings (C & B–March.) 1700 w.

10933. Safe Scaffolding. Ill. (C & B–March.) 1700 w.

10934. Designs in Slate Roofing. Ill. (C & B–March.) 1100 w.

10956. The Architect and His Materials. George P. Merrill (A A–March 4.) 2200 w.

10958. Sketches of Italian Architects—Palladio. Arthur Gilman (A A–March 4.) 3000 w.

*10999. The Windows in York Cathedral (A L–Feb. 24.) 1600 w.

*11000. Our Duty in Respect of Ancient Buildings. W. W. Robertson (A L–Feb. 24.) 6500 w.

Serials.

2285. Construction. Ill. M. Viollet-le-Duc (A A–Began Feb. 20, 1892—19 parts to date—15 cts. each).

7121. Office-Help for Architects. George Hill (A A–Began Oct. 8—7 parts to date—15 cts. each).

10290. Notes on the Use of Iron and Steel in Building Construction. J. W. Ashcroft (I–Began Jan. 27—Ended Feb. 10—2 parts—30 cts. each).

10673. Architectural Terra Cotta (B B–Began Jan.—1 part to date—30 cts).

10682. The Chateaux of France. Ill. Louis H. Gibson (S–Began Feb.—1 part to date—30 cts).

10756. The Languedocian School of Architecture. Ill. Anthyme Saint Paul (A A–Began Feb. 18—3 parts to date—15 cts. each).

10960. The Origin of Building. H. J. Williams (A & B–Began March 4—1 part to date—15 cts).

CIVIL ENGINEERING.

†10525. "Overhead Reservoir." Ill. (I E–Jan. 14.) 1600 w.

10533. Anti-Freezing Soda-Mortar (E N–Feb. 16.) 500 w.

10534. Some Recent Examples of Monier Arch Construction. Ill. (E N–Feb. 16.) 700 w.

10538. A 35-Ton Traveling Crane for Harbor Work. Ill. (E N–Feb. 16.) 800 w.

10539. Letting Highway Bridge Contracts. Editorial and Letters (E N–Feb. 16.) 4500 w.

10608. The South Halsted Street Lift Bridge, Chicago. Ill. (R R–Feb. 18) 2700 w.

*10636. Manchester Canal Financial Difficulties. Editorial (E–Feb. 10.) 1300 w.

10651. The Panama and Nicaragua Canals. F. R. Brainard (Sc A–Feb.25.) 1800 w.

*10674. Note on the Compressive Resistance of Brick (B B–Jan.) 500 w.

10691. The Actual Resistance of Bearing Piles (E N–Feb. 23.) 3000 w.

10692. Concrete Conduit in Tunnel of the Santa Aña Valley Irrigation Co., Orange County, Cal. Ill. H. C. Kellogg (E N–Feb. 23.) 600 w.

10707. A Controverted Question in Road Construction. James Owen (R G–Feb. 24.) 2500 w.

10710. The Nicaragua Canal. A. G. Menocal (R G–Feb. 24.) 3000 w.

†10717. Panama: The Story of a Colossal Bubble. Ernest Lambert (F–March.) 5200 w.

10750. The Corinth Canal. Editorial (E R–Feb. 25.) 900 w.

10751. A Method of Tunnel Alignment. H. F. Dunham (E R–Feb. 25.) 1800 w.

†10775. Vizagapatam Harbor. G. E. Moore (I E–Jan. 21.) 1300 w.

*10781. River Severn Improvements (Eng L–Feb. 17.) 2000 w.

†10870. Vizagapatam Harbor. G. T. Walch (I E–Jan. 28.) 2000 w.

*10923. Paving Brick; Their Manufacture and Use, with Discussion. W. S. Williams (P–March.) 3000 w.

10938. The Restoration of the Cable Ends of the Covington and Cincinnati Suspension Bridge. Abstract of paper by G. Bouscaren (E R–March 4.) 800 w.

10959. The Tower Bridge, London (A A–March 4.) 1800 w.

11025. Reconstructing a Pittsburg Bridge (R G–March 3.) 700 w.

*11033. Road Improvement in New York. Ill. Roswell P. Flower (G R–Feb.) 1500 w.

*11034. Good Roads and School Attendance. Francis J. Cheney (G R–Feb.) 1000 w.

*11035. Wheel-Tires and Axles. How They Can Be Made to Keep the Road Smooth. Ill. William A. Sweet (G R–Feb.) 500 w.

*11053. The St. Clair Tunnel. Ill. (R W–Feb.) 2200 w.

11090. The Construction and Maintenance of Howe Truss Bridges. Charles H. Nichols (E N–March 9.) 1800 w.

11091. An Interesting Example of False Work Construction. Ill. J. F. Jackson (E N–March 9.) 1800 w.

Serials.

8671. MacAdam and Telford Roads. Ill. Isaac B. Potter (G R–Began Nov.—2 parts to date—30 cts. each).

9523. Maintenance of Roads in France. Arthur Lagron (P–Began Jan.—3 parts to date—30 cts. each).

10455. The Bridges of the Manchester Canal. Ill. (E–Began Feb. 3—2 parts to date—30 cts. each).

10665. The Panama Canal. Ill. (I L–Began Feb. 10—Ended Feb. 17—2 parts—30 cts. each).

10780. Dredging. W. H. Wheeler (Eng L–Began Feb. 17—1 part to date—30 cts).

11036. Staten Island Highways. Ill. (G R–Began Feb.—1 part to date—30 cts).

ELECTRICAL MISCELLANY.

10513. Edison's New Art of Generating Electricity. Ill. (Sc A–Feb. 18.) 1000 w.

*10528. Transformers and Sub-Stations. W. H. Trentham (E E L–Feb. 3.) 800 w.

†10552. Note on the Descriptive Strength of Dielectrics. Ill. Charles Proteus Steinmetz (T A I E E–Feb.) 3600 w.

*10616. Theory and Practice in Electrical Science. Alexander Siemens (El–Feb. 10.) 900 w.

*10637. The Practical Measurement of Alternating Electric Currents. J. A. Fleming (E–Feb. 10.) 1800 w.

10660. A Simple System for Operating Electric Clocks. Ill. R. G. Brown (E E N Y–Feb. 22.) 500 w.

10661. On Distribution of Potential. Ill. George P. Huhn (E E N Y–Feb. 22.) 400 w.

10667. The Future Ohm, Ampere, and Volt. H. S. Carhart (Sc–Feb. 17.) 1200 w.

10671. Shunt Motors. W. D. Weaver (E W–Feb. 25.) 1600 w.

10700. MacLeod's Improvements in Accumulators. Ill. (W E–Feb. 25.) 600 w.

10701. Experiments with Electric Waves (W E–Feb. 25.) 900 w.

10761. Nikola Tesla (B J C–Feb. 25.) 1000 w.

*10769. Giraud's Thermo-Electric Stove. Ill. (E L–Feb. 17.) 500 w.

*10794. The Magnetic Properties of Substances at Various Temperatures. Ill. P. Curie (El–Feb. 17.) 200 w.

*10807. The Practical Measurement of Alternating Electric Currents. Ill. J. A. Fleming (E–Feb. 17) 1500 w.

*10808. The Development and Transmission of Power from Central Stations. Prof. Unwin (E–Feb. 17.) 4800 w.

10816. Electric Power from Niagara Falls. Prof. George Forbes Talks Interestingly. J. A. M. (E R N Y–Feb. 25.) 2200 w.

10820. One Year of Electricity.—Gleanings by the "Electrical Review" During the Past Year. Ill. (E R N Y–Feb. 25.) 10,000 w.

10821. The Place of Electricity in the Modern Office Building (E R N Y–Feb. 25.) 1200 w.

*10830. Novel Effects of the Electric Discharge. Lord Armstrong (E R L–Feb. 17.) 3200 w.

10836. The Works of the Eddy Electric Manufacturing Company at Windsor, Conn. Ill. (E R N Y–March 4.) 1800 w.

10837. Is the Steam Locomotive an Electric Generator? (E R N Y–March 4.) 600 w.

10843. Conductors and Insulators. Reginald K. Fessenden (E W–March 4.) 2000 w.

10845. The Application of the Electric Motor in Commercial Industries. Ill. (E W–March 4.) 800 w.

10847. Growth of American Electrical Industries (E W–March 4.) 400 w.

10862. A Wire Gage Chart for Determining the Ampere Turns on Shunt Magnets. Ill. William R. C. Corson (E E N Y–March 1.) 750 w.

10863. The Scott-Sisling System for Accumulator Installations. Ill. W. B. Sisling (E E N Y–March 1.) 300 w.

10885. Storage Batteries in Practice. J. R. Pumpelly (S E–Feb. 25.) 2000 w.

10943. Storage Batteries, Secondary Cells, or Accumulators. W. B. Shaw (C E N–March.) 1800 w.

10954. The Effect of Short Circuits on Dynamos (P S–March.) 1500 w.

10961. Poles. Ill. G. A. Wall (S R N–March 4.) 1900 w.

*10981. The Development and Transmission of Power from Central Stations. W. C. Unwin (El–Feb. 24.) 4500 w.

*10992. Lord Kelvin's New Engine-Room Watt-Meter (E E L–Feb. 24.) 500 w.

*10994. How to Design a Small Motor. Ill. E. Meylan (E E L–Feb. 24.) 3000 w.

*10996. Ships' Electrical Fittings for Lighting, Signalling, Telegraphing, and for Motive Power. Ill. L. Newitt (E E L–Feb. 24.) 3600 w.

*10998. Moissau's Electric Furnace (E E L–Feb. 24.) 1000 w.

*11016. The Personnel of the Business Side of Electrical St. Louis. Ill. (E I-March.) 2800 w.

*11018. Power Transmission by Electric Motors in the Fraser and Chalmers' Plant. Ill. (E I-March.) 1000 w.

11045. Wrought Iron vs. Cast Iron for Field Magnet Frames. A. D. Adams (E A-March 4.) 600 w.

*11052. Heating in Voltaic Cells. Ill. T. H. Muras (E R L-Feb. 24.) 450 w.

11063. Remarks Concerning Power Transmission from the Economic Standpoint. L. B. Stillwell (E E N Y-March 8.) 1800 w.

11064. Long Distance Transmission of Power. Charles S. Bradley (E E N Y-March 8.) 1200 w.

11066. Power Transmission for Central Stations. Louis Bell (E E N Y-March 8.) 2700 w.

11077. An Induction Coil for Alternating Currents. Ill. R. W. Wood (Sc A-March 11.) 1800 w.

11080. Electrical Transmission (M N-March 1.) 450 w.

Serials.

2784. Insulated Electric Conductors. Ill. James Bowstead Williams (E E N Y-Began March 16, 1892—19 parts to date—15 cts. each).

5543. Light and Power Stations. Robb Mackie (E R N Y-Began July 23—14 parts to date—15 cts. each).

9374. Laminated or Divided Iron and Other Metallic Masses in Electromagnetic Apparatus. Thomas D. Lockwood (E E N Y-Began Jan. 4—Ended Feb. 22—8 parts—15 cts. each).

9771. What Is Electricity? S. F. Walker (E E L-Began Jan. 6—3 parts to date—30 cts. each).

10147. William Wallace and his Contributions to the Electrical Industries. Ill. W. J. Hammer (E E N Y-Began Feb. 1—Ended Feb. 22—4 parts—15 cts. each).

10170. Electrical Oscillations of High Frequency. Ill. Erwin S. Ferry (E W-Began Feb. 4—3 parts to date—15 cts. each).

10325. The Electrical side of St. Louis. Ill. (E W-Began Feb. 11—4 parts to date—15 cts. each).

10600. Electrical Measurements. Ill. George D. Shepardson (S R R-Began Feb.—1 part to date—30 cts).

10615. On the Determination of the Insulation Resistance and of Faults in Electrical Plants During the Working. Ill. O. Froelich (El-Began Feb. 10—Ended Feb. 24—3 parts—30 cts. each).

10659. Influence of Frequency in the Working of Alternate Current Transformers. Ill. Charles Steinmetz (E E N Y-Began Feb. 22—2 parts to date—15 cts. each).

10995. On Testing and Working Alternators. W. M. Morley (E E L-Began Feb. 24—1 part to date—30 cts).

11046. Some Experiences with the Alternating System. R. H. Sterling (E A-Began March 4—1 part to date—15 cts).

ELECTRIC LIGHTING.

†10551. Discussion of Caryl D. Haskin's paper on "Electrical Recording Meters" (T A I E E-Feb.) 5400 w.

†10553. The Most Economical Age of Incandescent Lamps. Carl Hering (T A I E E-Feb.) 3000 w.

10662. Incandescent Lamp Litigation.—The Goebel Claims Rejected (E E N Y-Feb. 22.) 7500 w.

10666. Edison Lamp Patent Stands.—Judge Colt's Decision in the Beacon Company's Case (E N Y-Feb. 22.) 2500 w.

10672. Handy Wiring Tables (S E-Feb. 18.) 300 w.

*10739. The Johnstone System of Electrical Underground Conduits. Ill. (I-Feb. 17.) 1500 w.

*10793. Concentric Wiring. Sam Mavor (El-Feb. 17.) 1700 w.

10817. The Largest Arc Light Plant in the World.—The Municipal Electric Lighting and Power Company of St. Louis. Ill. (E R N Y-Feb. 25.) 2200 w.

10818. Edison Again.—Judge Colt Grants Another Injunction (E R N Y-Feb 25.) 8000 w.

10823. The Durability of Underground Wires. Herbert Laws Webb (E R N Y-Feb. 25.) 1000 w.

*10829. Installation for Electric Light and Power at Benatek, Bohemia (E R L-Feb. 17.) 1500 w.

10838. Rules for Electric Light Work Adopted at St. Louis (E R N Y-March 4.) 6000 w.

10858. An Historic Edison Plant. S. S. "Columbia." Ill. (E E N Y-March 1.) 700 w.

10859. Electric Lighting in Churches:—St. Francis Xavier's, New York. Ill. John McGhie (E E N Y-March 1.) 900 w.

10872. Glowing of Disconnected Incandescent Lamps. Ill. N. S. Amstutz (E N Y-March 1.) 600 w.

10874. A Model Lighting Station.—The Brooklyn Edison Illuminating Company's New Plant on Gwinnett Street. Ill. (E N Y-March 1.) 2600 w.

10884. Steam and Lighting Plant of the Masonic Temple Building, Chicago. Ill. (S E-Feb. 25.) 1200 w.

*10980. Latitude and the Load-Factor. Ill. E. Tremlett Carter (El-Feb 24.) 1100 w.

*10986. Indirect Lighting (G W-Feb. 25.) 1600 w.

*10990. Electricity at the Theatres. Ill. (E E L-Feb. 24.) 1100 w.

*10993. Pioneer Electric Lighting in South America (E E L-Feb. 24.) 900 w.

*10997. Electric Light at the Brussels Post Office (E E L-Feb. 24.) 1100 w.

*11015. The Stations of Electric Light Companies of St. Louis. Ill. (E I-March.) 2000 w.

11019. Dangers from Gas in Electrically Lighted Cities. Ill. M. P. Jousselin (W E-March 4.) 5000 w.

11044. Relation of Insurance to Electric Lighting and Power. William Brophy (E A-March 4.) 1600 w.

11065. The Incandescent Lamp from a Commercial Standpoint. Calvert Townley (E E N Y-March 8.) 1800 w.

11067. Underground Conduits and Conductors and the Experiences of Electric Lighting Companies of New York City. William H. Brown (E E N Y-March 8.) 1800 w.

11068. Thermal Storage for Central Stations. George Forbes (E E N Y-March 8.) 1500 w.

11069. President Ayer's Address (E E N Y-March 8.) 2000 w.

11070. The Tesla Lecture in St. Louis (E E N Y-March 8.) 2000 w.

11096. Panel Distribution Board. Ill. (E R N Y-March 11.) 600 w.

Serials.

6709. Electric Light and Power. Ill. Arthur F. Guy (E E L-Began Sept. 9—16 parts to date—30 cts. each).

9531. Suggestions for Metering Devices. Ill. S D. Mott (E W-Began Jan. 14—4 parts to date—15 cts. each).

9906. Electric Light and Gas. Ed. C. de Segundo (E R L-Began Jan. 13—3 parts to date—30 cts. each).

10403. Evolution of Electric Lighting. W. H. Wakeman (M G-Began Feb. 11—Ended Feb. 18—2 parts—15 cts. each).

10844. The Design of a Central Station for Incandescent Electric Lights. E. P. Roberts (E W-Began March 4—1 part to date—15 cts).

GAS ENGINEERING.

*10545. Experimenting with a View to the Development of Gasholder Construction. E. L. P. (J G L-Feb. 7.) 1000 w.

10578. The Fitch Process. Ill. (P A-Feb. 15.) 800 w.

10650. New Method of Gas Supply for New York City (Sc A-Feb. 25.) 1000 w.

10748. Experiments on Removing Sulphur from Purified Gas,—with Discussion. Mr. Goodno (A G L J-Feb. 27.) 2800 w.

10749. Reports with Discussion. Robert N. Bush (A G L J-Feb. 27.) 3000 w.

*10800. Inaugural Address of C. C. Carpenter (G W-Feb. 18.) 6500 w.

*10824. Cooking-Gas at Copenhagen (J G L-Feb. 14.) 1600 w.

*10825. The Use of Air for the Purification of Gas. Norton H. Humphreys (J G L-Feb. 14.) 2100 w.

10865. The Gas Engine (Sc A S-March 4.) 700 w.

10929. Effects of the Trolley System on Gas and Water Pipes, with Discussion. H. A. Allyn (A G L J-March 6.) 5400 w.

10930. Recording Pressures on Mains and Services, with Discussion. S. J. Fowler (A G L J-March 6.) 5600 w.

10931. The New Plant of the Altoona (Pa.) Gas Company. T. W. Cole (A G L J-March 6.) 1500 w.

*10987. A Look into the Distribution Department. Paulos Thieman (G W-Feb. 25.) 5400 w.

HYDRAULICS.

†10523. Mr. Doig's Report on the Shone System at Rangoon. Xen (I E-Jan. 14.) 550 w.

†10524. Sanitary Engineering in India. Pump (I E-Jan. 14.) 500 w.

10541. Reduction of Water Consumption by Meters (E N-Feb. 16.) 1700 w.

*10544. Presidential Address of W. A. Valon (J G L-Feb. 7.) 7500 w.

10548. New England Water Power (P M-Feb. 16.) 800 w.

†10583. Artesian Waters in the Arid Region. Ill. Robert T. Hill (P S M-March.) 4300 w.

*10633. Discussion of William Matthews' paper—"Description of the Pumping Engines and Water Softening Machinery at the Southampton Water Works" (E-Feb. 10.) 5000 w.

*10654. The Jet Water Wheel. C. R. Tompkins (Am M-Jan. 1.) 1000 w.

10729. Niagara Must Go to Work (P M-Feb. 23.) 900 w.

10752. The Formation of Sand Filters. Ill. (E R-Feb. 25.) 2000 w.

*10785. Joseph Moore's Patent Hydraulic Pumping Arrangement (C G-Feb. 17.) 2000 w.

*10806. Water Power of the Periyar River (E-Feb. 17.) 900 w.

10877. Niagara Falls in Harness (P A-March 1.) 2000 w.

10897. The Discharge of the Niagara River. Ill. (E N-March 2.) 3400 w.

*10906. The Dam and Power at Holyoke, Mass. Ill. (R M-Feb.) 1200 w.

10969. The Irrigation Question from a Botanical Standpoint. Frederick Vernon Coville (E M J-March 4.) 1000 w.

11072. Hydraulic Reaction Motors.—Abstract of paper by De Volson Wood (A M-March 9.) 1300 w.

11074. The Hydro-Electric Distribution of Power and Electric Energy. Ill. E. Hospitalier (Sc A S-March 11.) 1700 w.

11088. A Water Filtration Plant at Leeuwarden, Holland. Ill. (E N-March 9.) 900 w.

Serials.

9998. American Turbine Water-Wheels. Ill. Samuel Webber (Ir Age-Began Jan. 26—Ended March 2—5 parts—15 cts. each).

10988. Water-Power Utilization. Ill. W. H. Booth (E L-Began Feb. 24—1 part to date—30 cts).

INDUSTRIAL CHEMISTRY.

*10627. The Distillation of Coal. Pierre Mahler (C G-Feb. 10.) 350 w.

*10744. The Manufacture of Nitric Acid (I L-Feb. 17.) 1800 w.

*10827 Note on the Purification of Mercury. Ill. M. W. Jaeger (E R L-Feb. 17.) 800 w.

†11057. The Effect of Decomposing Matter on Natural Phosphates. N. T. Lupton (J A C S-Dec.) 1600 w.

11062. Carborundum:—Its Manufacture and Use. Ill. E. G. Acheson (E E N Y-March 8.) 2000 w.

Serials.

11049. The Applications of Ozone (E R L-Began Feb. 24—1 part to date—30 cts).

INDUSTRIAL SOCIOLOGY.

*10500. The Industrial Problem in Australia. Ill. Edmund Mitchell (E Mag-April.) 3000 w.

*10503. Fallacies and Facts as to Immigration. John B. Weber (E Mag-April.) 3000 w.

*10504. The Dearness of "Cheap" Labor. David F. Schloss (E Mag-April.) 3000 w.

10579. Wages. Editorial (A M M-Feb.) 1000 w.

†10580. The Taxation of Ground Rents. J. Powell Williams (N C-Feb.) 7300 w.

*10635. The Liability of Employers for Accidents to Workmen. Editorial (E-Feb. 10.) 1500 w.

*10688. Strikes, Their Effects and Remedies. J. H. Peter (S-Feb.) 1300 w.

*10689. National Organization of Quarrymen. Sylvester Marshall (S-Feb.) 2000 w.

†10718. A New Era for the United States. George W. Medley (F-March.) 3000 w.

†10721. The Condition of Wage-Earning Women. Clare de Graffenreid (F-March.) 6800 w.

10723. Direct Trade and Agriculture. I. W. Avery (M R-Feb. 24.) 1300 w.

*10875. Where Do Wages Come From? (J G L-Feb. 21.) 2000 w.

*10983. The Forty-Eight Hour Week. Editorial (Eng L-Feb. 24.) 2000 w.

11089. The Development of Technical Societies. John Birkinbine (E N-March 9.)1400 w.

Serials.

11056. The Social Quagmire and the Way Out of It. Alfred R. Wallace (A-Began March —1 part to date—45 cts).

LANDSCAPE ENGINEERING.

10917. Villa-Garden Landscapes. James MacPherson (Am G-Feb.) 1000 w.

10945. Grasses for Lawns. C. L. Allen (Am A-March.) 600 w.

MARINE ENGINEERING.

10517. To Encourage American Shipbuilding (B I S-Feb. 15.) 800 w.

10554. Direct Foreign Trade for the South. H. B. Crosby (M R-Feb. 17.) 1200 w.

10586. Steamship Manitou, Lake Michigan and Lake Superior Transportation Co. Ill. (M R C Feb. 16.) 2200 w.

*10634. Thornycroft's Screw Turbine Propeller. Ill. (E-Feb. 10) 1000 w.

*10686. Decadence of American Shipping. Alexander H. Smith (S-Feb.) 1400 w.

*10731. The Abysmal Depths of the Sea. Ill. J. Carter Beard (Cos-March.) 2200 w.

*10735. The British Navy. Ill. S. Eardley-Wilmot (Cos-March.) 4800 w.

10771. Seaboard Accommodates Secretary Foster. Alexander R. Smith (Sea-Feb. 23.) 1500 w.

10772. The American Line. Ill. (Sea-Feb. 23.) 1800 w.

10864. The Monterey. Ill. (Sc A S-March 4.) 900 w.

10866. American Ocean Commerce. Editorial (Sc A-March 4.) 1000 w.

10869. Raising the Flag on the Steamship New York. Ill. (Sc A-March 4.) 1200 w.

10894. Our First Battle-Ship—The Indiana. Ill. (Sea-March 2.) 550 w.

10895. Successful Preliminary Trial of the Steamship Howard Cassard (Sea-March 2.) 1100 w.

10926. F. W. Wheeler's No. 100.—A Great Shipping Record. Ill. (M R C-March 2.) 1800 w.

*10970. Chicnecto Ship Railway.—History and Manner of the Transportation of Ships (R A E J-March.) 1800 w.

*10984. The Protection of English Commerce. Editorial (Eng L-Feb. 24.) 1200 w.

11020. The Bernstein Sculling Propeller. Ill. (Am S-March 2.) 800 w.

*11042. The Coaling of Ocean Steamers (C G-Feb. 24.) 1500 w.

11073. The German Dispatch Boat "Hohenzollern." Ill. (Sc A S-March 11.) 850 w.

11076. The Coming Naval Review. Editorial (Sc A-March 11.) 650 w.

11078. United States Steamship "Iowa." Ill. (Sc A-March 11.) 700 w.

11079. An Automatic Wave Subduer. Ill. (M N-March 1.) 650 w.

Serials.

10888 Marine Propulsion. Ill. I. McKim Chase (A M-Began March 2—1 part to date—15 cts).

10893. American Marine. William W. Bates (Sea-Began March 2—2 parts to date—15 cts. each).

MECHANICAL ENGINEERING.

*10567. The Durability of Wire Ropes. Ill. M. Jacob (C E-Feb.) 2700 w.

*10574. A Test of Viscosimeters. G. F. Wagner and K. B. Miller (S J E-Feb.) 1400 w.

10653. Conical vs. Cylindric Cam Boilers. S. W. Robinson (A M-Feb. 23.) 700 w.

10668. Proper Use of Terms. Carl Hering (E W-Feb. 25.) 1000 w.

10676. The Sellers 40-Ton Dock Crane. Ill. (Ir Age-Feb. 23.) 1000 w.

*10747. A Novel Cycle Boat —Zimer's Patent. Ill. (Inv-Feb. 18.) 900 w.

10770. The Serrell Improved Derrick. Ill. (A M & I W-Feb. 24.) 1200 w.

*10803. The Dredge-Steward Omnitelemeter. Ill (E-Feb. 17.) 1200 w.

10834. Superintendence. B. F. Spalding (A S-Feb. 25.) 2000 w.

10887. Rotary Protractor for Circular and Band Saws. Ill. John M. Richardson (A M-March 2.) 2100 w.

10889. Cylindrical vs. Conical Cam Rollers. Oberlin Smith (A M-March 2.) 500 w.

10898. The Price Current Meter. Ill. (E N-March 2.) 900 w.

10902. Concerning Rivet Values. Ill. Friedrich Edler von Emperger (E N-March 2.) 1100 w.

11031. Danger in the Grind-Stone (M & B-Feb.) 600 w.

11075. The Casting of a Large Steam Cylinder. Ill. (Sc A-March 11.) 700 w.

11084. A Weldless Chain. Ill. (I T R-March 9.) 2100 w.

Serials.

7865. Notes on Rope Driving. Ill. M. E. (A M-Began Nov. 10—3 parts to date—15 cts. each).

8318. Principles, Possibilities, Curiosities, and Limitations of the Crank Motion. Leicester Allen (Eng-Began Nov. 26—Ended Feb. 18—6 parts—15 cts. each).

11039. Helico Centrifugal Ventilator. Ill. M. Rateau (C G-Began Feb. 24—1 part to date—30 cts).

11082. Belts—The Influence of Speed—Dimensions of Pulleys. Charles A. Hague (E A-Began March 11—1 part to date—15 cts).

METALLURGY.

*10569. Going into Blast with a Coke Furnace. J. S. Kennedy (C E-Feb.) 4000 w.

*10625. The Durham Coke Trade (C G-Feb. 10.) 1000 w.

*10629. Soldering Aluminum (I-Feb. 10.) 600 w.

*10631. "Metallurgical Errors." J. E. Stead (I-Feb. 10.) 1900 w.

10640. The Bates Steel Process (A S-Feb. 18.) 700 w.

*10644. New South Wales Coke. Edward T. Pittman (A M S-Jan. 7.) 2500 w.

10679. Lamination in Metal (Ir Age-Feb. 23.) 900 w.

10712. The Production of the Precious Metals in 1892—Director of the Mint's Report (E M J-Feb. 25.) 1000 w.

10713. Use of Producer Gas for Drying and Roasting Ore at the Lixiviation Mill of the Holden Smelting and Milling Company, Aspen, Colo. Willard S. Morse (E M J-Feb. 25.) 550 w.

*10741. Some Remarks on Ore Imports from Spain in 1892. Walter J. May (I-Feb. 17.) 1000 w.

*10778. The Bates' Process—Letters from Vulcan and H. Augustus Guy (I & S-Feb. 18.) 900 w.

*10779. The Swedish Iron Industry (I & S-Feb. 18.) 1600 w.

*10788. Ferro-Metallic Compounds (C G-Feb. 17.) 1800 w.

10832. The Effect of Cold on Iron and Steel (R R-Feb. 25.) 500 w.

10880. The Greene-Wahl Process of Manufacturing Manganese and Alloys of Manganese Free from Carbon. F. Lynwood Garrison (Ir Age-March 2.) 2300 w.

10881. Titaniferous Ores in the Blast Furnace. Auguste J. Rossi (Ir Age-March 2.) 2100 w.

10883. A Visit to the Property and Plants of the Canada Iron Furnace Company (Ir Age-March 2.) 6000 w.

10890. Wanted a Wire Gage. Oberlin Smith (A M-March 2.) 1100 w.

10966. The Future of Platinum. Editorial (E M J-March 4.) 900 w.

*10975. Description of a 28-Inch Steel Mill, with Shears and Subsidiary Plant for the New British Iron Company, Limited, Birmingham. Jeremiah Head (I-Feb. 24.) 2200 w.

*10976. Chinese Metallurgical Undertakings. C. T. Gardner (I-Feb. 24.) 1400 w.

*10977. Ingot Molds. James Riley (I-Feb. 24.) 1200 w.

*10985. Coal and Coke Conveyors for Retort Houses and Coal Stoves. Ill. (Eng L-Feb. 24.) 1500 words.

10989. The Lead Ore Problem. Editorial (M I T-March 2.) 1100 w.

*11038. Low Grade Surface Hematite Ores and Their Treatment. Walter J. May (C G-Feb. 24) 1500 w.

*11050. Palladium Plating (E R L-Feb. 24.) 900 w.

†11058. The Constitution of Nickeliferous Pyrrhotite. H. S. Emmens (J A C S-Dec.) 1500 w.

11083. Pig Iron Possibilities of Marquette. Richard A. Parker (I T R-March 9.) 2500 w.

Serials.

9459. The Manufacture of Coke. John Fulton (C E-Began Jan.—2 parts to date—30 cts. each).

10266. Castings. S. Bolland (F D-Began Dec.—2 parts to date—15 cts. each).

10275. The Analysis of Iron and Steel. J. Parry and J. J. Morgan (I L-Began Jan. 27—3 parts to date—30 cts. each).

10410. Development of the Coke Industry by Utilization of By-Products. B. Leistikow (A M & I W-Began Feb. 10—Ended Feb. 17—2 parts—15 cts. each).

10630. Engineer's Tests for Iron, Considered from an Ironmaster's Point of View. Thomas Morris (I-Began Feb. 10—Ended Feb. 17—2 parts—30 cts. each).

10892. Some Points in Silver-Milling by Amalgamation. C. H. Aaron (M S P-Began Feb. 25—2 parts to date—15 cts. each).

10971. The Resistance of Metal to Shear. Ill. H. V. Loss (R A E J-Began March—1 part to date—30 cts).

MILITARY ENGINEERING.

10514. The Fontainebleau Proving Grounds. Ill. (Sc A-Feb. 18.) 2000 w.

†10550. The Uselessness of Gibraltar. W. Laird Clowes (F R-Feb.) 4000 w.

*10585. The Navy of the United States. H. W. Raymond (Ch-March) 3000 w.

*10619. Cordite. Editorial (Eng L-Feb. 10.) 1000 w.

10648. An Important Report upon Our New Navy, by Chairman Herbert (B I S-Feb. 22) 1000 w.

10678. The New Armor Specifications (Ir Age-Feb. 23.) 3000 w.

†10716. Hawaii and Our Future Sea Power. A. T. Mahan (F-March.) 4800 w.

†11059. The Army Organization Best Adapted to a Republican Form of Government, Which Will Ensure an Effective Force. Sydney E. Stuart (J M S I-March.) 18,900 w.

†11060. Telegraph in War. Jas. A. Swift (J M S I-March.) 3200 w.

11081. Gun and Shell Making. James Eastus Price (M N-March 1.) 1500 w.

Serials.

8241. Assault and Battery. Ill. A. Ewbank (I E-Began Oct. 22—12 parts to date—45 cts. each).

9347. Notes of Lectures on Artillery in Coast Defense. A. C. Hansard (J M S I-Began Jan —2 parts to date—45 cts. each).

10738. The Development of American Armor-Plate. Ill. F. Lynwood Garrison (M-Began Feb. 15—1 part to date—30 cts).

10957. Chinese Curios. Consul Bedloe (A A-Began March 4— 1 part to date—15 cts).

MINING.

10516. Dakota Tin Mines. Wilder Grahame (Min-Jan.) 1400 w.

10531. Spanish-American and Other Cuban Iron Mines. Ill. S. P. Ely (I T R-Feb. 16.) 3500 w.

10532. Wire Rope Tramway at the San Juan Mines. Ill. (E N-Feb. 16.) 800 w.

10556. Report of Inspector of Mines in West Virginia (M R-Feb. 17.) 600 w.

10560. Lead and Zinc Mines in the South. Ill. (T-Feb. 15.) 300 w.

10561. A Brief Golden Dream. Dan De Quille (E M J-Feb. 18.) 1000 w.

10562. Lead and Zinc Mining Industry of Missouri and Kansas in 1892. J. R. Holibough (E M J-Feb. 18.) 1100 w.

10563. The Mines of Sierra Mojada, Mexico. Eugene O. Fechet (E M J-Feb. 18.) 2500 w.

10564. Graduates of Mining Schools. Samuel B. Christy (E M J-Feb. 18.) 1900 w.

10565. The Persistence of Ores in Lodes in Depth.—The Empire Lode. H. M. Beadle (E M J-Feb. 18.) 300 w.

*10566. The Economic Geology of Tin. Ill. H. A. Wheeler (C E-Feb.) 1200 w.

*10571. The Best Types of Safety Lamps for Gas Testing Purposes. Ill. Alexander Dick (C E-Feb.) 800 w.

*10572. On Metal Mining. Ill. M. C. Ihlseng (C E-Feb.) 1000 w.

*10573. On Mining Machinery.—Hoisting Engines. F. W. Ewald (C E-Feb.) 1200 w.

10605. The Comstock Lode a Devourer of Forests. Ill. Dan De Quille (M I T-Feb. 16.) 1900 w.

*10624. Some Remarks on Wasted Coal. Walter J. May (C G-Feb. 10.) 1500 w.

*10642. The Mount Stewart Lead and Silver Mine (A M S-Jan. 7.) 1200 w.

*10643. Gold in Borneo.—A Field for Enterprise (A M S-Jan. 7.) 1500 w.

*10646. The White Cliffs Opal Field. (N. S. W.) John B. Jaquet (A M S-Jan. 21.) 2500 w.

10675. Where the Columbia River Gold Comes From. H. S. Back (M S P-Feb. 18.) 1000 w.

10714. The Gold Mining Industry of Nova Scotia in 1892 (E M J-Feb. 25.) 500 w.

10715. A Method of Transferring Surface Alignment Underground. Ill. L. Kuhn (E M J-Feb. 25.) 500 w.

†10720. The Cost of Silver and the Profits of Mining. J. D Hague (F-March.) 3700 w.

10725. Phosphate Developments About Fort Meade. Nodule (M R-Feb. 24.) 1000 w.

*10743. The Coal Trade Crisis in South Wales. Editorial (I L-Feb. 17.) 1300 w.

*10783. Mexico an Iron Producing Country. Editorial (I C T-Feb. 17.) 1200 w.

*10787. The Syndicating of the Coal Industry (C G-Feb. 17.) 2000 w.

*10789. The Carmaux-Albi Coalfield, France. Jules Laromiguière (C G-Feb. 17.) 2000 w.

*10797. On the Detection and Estimation of Small Proportions of Fire-Damp, Petroleum Vapor, and Other Inflammable Gas or Vapor in the Air. Ill. Frank Clowes (J S A-Feb. 17.) 10,000 w.

10882. The Biwabik Mine. U. V. Winchell and John T. Jones (Ir Age-March 2.) 400 w.

10891. Mineral Wealth of Eastern Oregon. D. E. Cummins (M S P-Feb. 25.) 1250 w.

10907. Copper Mining in the South. Ill. James G. Parks (T–March 1.) 2000 w.

10908. Iron Deposits in Texas. W. J. Singletary (T–March 1.) 750 w.

10924. Tin in the Malay Peninsula.—Report of Consul Wildman (A M & I W–March 3.) 2100 w.

10967. Geological Occurrence of the Broken Hill Ore Deposits. Ill. E. F. Pittman (E M J–March 4.) 800 w.

10968. The Relation Between Ore Deposits and Their Inclosing Walls. Harold W. Fairbanks (E M J–March 4.) 1600 w.

11012. The Coal and Iron Resources of Texas. W. S. A. (M R–March 3.) 1200 w.

*11040. Mining Labor in the United States (C G–Feb. 24.) 1500 w.

*11041. Spontaneous Combustion in Coal Mines. Arnold Lupton (C G–Feb. 24.) 2500 w.

11097. An Abnormal Borax Deposit. Ill. (M S P–March 4.) 400 w.

Serials.

10232. The Present Status of Natural Gas in Ohio. Edward Orton (A M & I W–Began Feb. 3—Ended Feb. 17—3 parts—15 cts. each).

10584. Scientific Phases of Mining. Albert Williams, Jr. (Ch–Began March—1 part to date—30 cts).

10623. General Theory of Turbo-Engines, with Special Reference to Mine Ventilators. M. Rateau (C G–Began Feb. 10—2 parts to date—30 cts. each).

10645. Croydon (U. Q.) (A M S–Began Jan. 14—2 parts to date—30 cts. each).

10724. The Phosphate Mines of Canada. H. B. Small (M R–Began Feb. 24—2 parts to date—15 cts. each.

10978. The Lührig Process of Washing and Treating Coal. James I'Anson (I–Began Feb. 24—1 part to date—30 cts.

RAILROADING.

*10505. Would the Pan-American Road Pay? Ill. Charles P. Yeatman (E Mag–April.) 3000 w.

10511. English Locomotives and Railway Management. W. H. Booth (A M–Feb. 16.) 1400 w.

10518. Railroads Toward the North Pole (B I S–Feb. 15.) 700 w.

10527. Use of Streets for Railroad Purposes.—Rights of Abutting Property Owners. L.L. B. (S R N–Feb. 18.) 1300 w.

10536. The American Type of Freight Cars for European Railways (E N–Feb. 16.) 500 w.

10540. An English View of American Railways and Locomotives. Editorial and Letter (E N–Feb. 16.) 5000 w.

†10549. The New Railway Rates. J. Stephen Jeans (F R–Feb.) 6500 w.

10555. An Important Railroad Project. (M R–Feb. 17.) 550 w.

10575. Trestles on the Norfolk and Western. Ill. Emile Low (R G–Feb. 17.) 550 w.

10576. The New Orleans Bridge (R G–Feb. 17.) 600 w.

10577. The Western Section of the Trans-Siberian Railroad. Michel Nicolaevich Ghercevanof (R G–Feb. 17.) 2300 w.

*10587. The Rezende Viaduct of Old Rails. Ill. (A J R A–Feb.) 200 w.

10595. Should Sleeping Car Rates Be Reduced. Editorial (R A–Feb. 17.) 900 w.

10596. Railway Companies and their Employés. O. D. Ashley (R A–Feb. 17.) 3800 w.

10597. New Sheep Pens.—C. B. & Q. Railroad. Ill. (R A–Feb. 17.) 1000 w.

*10598. The Los Angeles Consolidated Electric Railway. Ill. (S R R–Feb.) 2000 w.

*10599. The Broadway Cable.—The Most Difficult Enterprise Undertaken by a Street Railway. Ill. (S R R–Feb.) 3500 w.

*10601. A Chinese Cable Line. Ill. (S R R–Feb.) 700 w.

*10602. An Argument in Favor of Ground Plates as Against a Continuous Copper Return. J. F. E. (S R R–Feb.) 2000 w.

10603. Street Railways and the West (S R G–Feb. 20.) 1400 w.

10604. The Green Electric Railway Patents. Ill. (S R G–Feb. 20.) 1500 w.

10606. Safety-Couplers. W. M. Mitchell (R R–Feb. 18.) 1800 w.

10607. Care of Foundation Brakes. Jas. Howard (R R–Feb. 18.) 1850 w.

10609. The Storehouse System of the Chicago, Burlington and Quincy Railroad (R R–Feb. 18.) 1600 w.

10610. Interlocking and Block Signal System.—C. & N. W. Ry. (R R–Feb. 18.) 1500 w.

10611. Co-operation of Railway Managers and Railway Commissioners. Editorial (R R–Feb. 18.) 800 w.

10612. Safety Appliance Legislation, with Bills (R R–Feb. 18.) 2500 w.

*10613. The Lighting of Railway Trains. Ill. Harry Pollitt (P Eng–Feb. 10) 2800 w.

*10620. English Locomotives in New South Wales. Ill. (Eng L–Feb. 10.) 800 w.

10652. Railways of Great Altitude in the Andes (Sc A S–Feb. 25.) 2600 w.

10663. Long Electric Railroads in Ohio (E E N Y–Feb. 22.) 1500 w.

10690. Special Train for the Emperor of Austria. Ill. (E N–Feb. 23.) 1200 w.

10693. Eight Years' Travel over Brooklyn Bridge (E N–Feb. 23.) 400 w.

10698. The Competitive Tests of the Westinghouse and New York Air Brakes on the N. Y. Central R. R. (E N–Feb. 23.) 6800 w.

10703. The West Albany Brake Trials, with Editorial (R G–Feb. 24.) 9000 w.

10704. The National Repeating Torpedo Signal. Ill. J. W. Lattig (R G–Feb. 24.) 2300 w.

10706. The Reading in the Hands of Receivers, with Editorial (R G–Feb. 24.) 2000 w.

10708. Blast Nozzles. Editorial (R G–Feb. 24.) 1300 w.

*10727. The Jaffa and Jerusalem Railway. Ill. Selah Merrill (Sc M–March.) 5700 w.

*10733. The Great Trans-Siberian Railway. Ill. Valerian Gribayédoff (Cos–March.) 4500 w.

10737. The Calumet Electric Railway. Ill. (S R G–Feb. 27.) 1000 w.

*10746. Electrical Block Interlocking Systems. R. Woods (I L–Feb. 17.) 1700 w.

10765. Rapid Transit in Boston —Address of Henry M. Whitney (M G–Feb. 25.) 10,000 w.

10766. Rapid Transit. Editorial (M G–Feb. 25.) 600 w.

*10767. The Electric Railway to the Saleve near Geneva. Ill. (E L–Feb. 17.) 900 w.

*10782. The Shortlands and Nunhead Railways. Ill. A. G. Drury (Eng L–Feb. 17.) 4000 w.

10798. Railway Labor Organizations. Editorial and List (R A–Feb. 24.) 1600 w.

10799. Shortages in Railroad Accounts. E. P. Higgins (R A–Feb. 24.) 2800 w.

*10804. Heating Railway Carriages. Ill. (E–Feb. 17.) 1800 w.

10831. Railway Safety Appliances. H. S. Haines (R R–Feb. 25.) 2600 w.

10833. Heating Railway Cars in France (R R–Feb. 25.) 1000 w.

†10848. Denver and Its Street Railways. Ill. (S R J–March.) 1400 w.

10868. A Monster Locomotive. Ill. (Sc A–March 4.) 500 w.

10873. An Electric Headlight. Ill. (E N Y–March 1.) 2500 w.

10899. The Abt Rack Railway in Syria (E N–March 2.) 700 w.

10901. Shocks in Air Brake Tests (E N–March 2.) 1000 w.

10903. Statistics Showing the Track Laying of 1892, and the Prospective Railway Construction of 1893, with Map (E N–March 2.) 7300 w.

*10909. Cutting Eccentric Keyways Before Wheels Are Placed Under Engines. Ill. Fred S. Hill (L E–March.) 1500 w.

*10911. Improvements at the Pittsburg Locomotive Works. Ill. J. A. H. (L E–March.) 1600 w.

*10912. Compound and Simple Engines. Hugh Sharp (L E–March.) 1300 w.

*10913. Setting Up Wedges, Keying Side-Rod Brasses, and Tramming Engines. G. K. W. (L E–March.) 1200 w.

*10914 The Brazilian Central Railway. Lewis Gleason (L E–March.) 1800 w.

*10915. The Greater Santa Fé Trail. A. S. (L E–March.) 2000 w.

10935. The Possibilities of Fraud in Present Systems of Freight Accounting. A. D. Oyer (R A–March 3.) 1200 w.

10936. Two Cents per Mile in Missouri. W. C. Brown (R A–March 3.) 2500 w.

10962. Wheel Gage Limits. Editorial. Ill. (R M M–March.) 1500 w.

10963. The Use of Compressed Air in Railroad Shops. Ill. F. M. Twombley (R M M–March.) 1000 w.

10964. Tests of Locomotives in Heavy Express Service. Ill. William Forsyth (R M M–March.) 2000 w.

10965. Oil Furnace for Blacksmith Shops.—Pittsburgh, Cincinnati, Chicago and St. Louis R. R. Ill. (R M M–March) 800 w.

*10974. Railway-Carriage Warming in England. Ill. (I–Feb. 24.) 2000 w.

*10982. Electrical Railways.—Abstract of paper by Edward Hopkinson (I C T–Feb. 24.) 1100 w.

*11003. The Railways and the Public. Editorial (I L–Feb. 24.) 3500 w.

11005. A Criminal Structure. Ill. Quintin McNab (R R–March 4.) 1200 w.

11006. Signaling Plant on the New York, New Haven and Hartford Railroad. Ill. (R R–March 4.) 700 w.

11008. The Law Governing the Application of Railway Safety Appliances (R R–March 4.) 800 w.

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*11017. Electric Lights for Railway Signals. Ill. (E I–March.) 1300 w.

11021. Northern Pacific Affairs.—Letter from "A Stockholder" (R G–March 3.) 1000 w.

11022. A Defect in Organization—Letter from L. E. H. (R G–March 3.) 1200 w.

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11026. The Reading Receivership. Editorial (R G–March 3.) 1300 w.

11027. "A Defect in Railroad Organization." Editorial (R G–March 3.) 1400 w.

11029 The Adventures of a Way-Bill. Thomas Coam (R G–March 3.) 1700 w.

*11043. Progress of Cable Traction. Editorial (Inv–Feb. 25.) 3000 w.

11047. The "Vulcanizing" Process for Preserving and Strengthening Poles, Cross-Arms, Ties, etc. H. C. Myers (E A–March 4.) 700 w.

*11048. Facts Concerning the Siemens Electric Railway of the Year 1879. A. M. Tanner (E R L–Feb. 24.) 1000 w.

*11054. Tube-Frame Goods Wagon. Ill. M. R. Jefferds (R W–Feb.) 2800 w.

*11055. Railway Freight Rates in England and America. M. R. Jefferds (R W–Feb.) 1400 w.

11092. The Monte-Generoso Rack Railway. (E N–March 9.) 450 w.

11093. Uniformity in Freight Car Draft Gear (E N–March 9.) 2500 w.

Serials.

5219. The $350,000 Cable Road and the $46,000 Electric Road. Cable Railways (S R J–Began July—5 parts to date—45 cts. each).

We supply copies of these articles. See introductory.

9739. New Railways in Spain. Ill. (I L-Began Jan. 6—2 parts to date—30 cts. each).

10111. The Liverpool Overhead Railway. Ill. (E E L-Began Jan. 20—Ended Feb. 10—3 parts—30 cts. each).

10378. The Evolution of the Railroad Turntable. Ill. C. A. Greenleaf (R G-Began Feb. 10—2 parts to date—15 cts. each).

10446. Permanent Way for Viaducts. Ill. Herbert Tatham Procter (R R-Began Feb. 11—Ended March 4—2 parts—15 cts. each).

*10502. English and American Railways. Wm. M. Acworth (E Mag-Began April—1 part to date—30 cts).

10709. Strikes or No Strikes (R G-Began Feb. 24—2 parts to date—15 cts. each).

11007. Transcontinental Railways. Edward P. Vining (R R-Began March 4—1 part to date—15 cts).

SANITARY ENGINEERING.

10694. The Effect of Frost on the Sewage Filtration Beds at South Framingham, Mass. (E N-Feb. 23.) 650 w.

10696. The Use of Sewage for Irrigation in the West. Editorial (E N-Feb. 23.) 1400 w.

10728. Plumbing for a City House. Ill. (Met W-Feb. 25.) 2300 w.

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†10905. The Need of Sanitary Supervision of Schools. Jerome Walker (San-March) 6000 w.

*10921. Notes on Sewage and Sewers. Louis H. Gibson (P-March) 1800 w.

10944. Importance of Pure Water. Henry Stewart (Am A-March.) 1300 w.

10973. The Dangers of City Refuse (Eng-March 4.) 1300 w.

Serials.

5358. Sewage Purification in America (E N-Began July 14—23 parts to date—15 cts. each).

8127. Ventilation and Heating. John S. Billings (E R-Began Nov. 19—4 parts to date—15 cts. each).

10425. A Healthy Home. Francis Vacher (S R-Began Feb. 1—2 parts to date—30 cts. each).

10557. Sewage Treatment and Sludge Disposal. W. Santo Crimp (E R-Began Feb. 18—Ended March 4—3 parts—15 cts. each).

10641. Purifying Water for Household Supply (S P-Began Feb. 15—1 part to date—15 cts).

10942. The New York Plumbing Regulations. Arthur Howell Napier (E R-Began March 4—1 part to date—15 cts).

STEAM ENGINEERING.

10521. Marine Engines on Land (S V-Feb. 15.) 1000 w.

10546. Spring Safety Valves (S E-Feb. 11.) 1000 w.

10547. Inspection and License Law. John A. Davis (S E-Feb. 11.) 900 w.

*10570. Cylindrical Boilers.—A Successful Plan for Increasing Their Efficiency. Ill. James Pollock (C E-Feb.) 1600 w.

*10589. Grates (A J R A-Feb.) 1500 w.

10594. Setting Engine Valves. Ill. (B J C-Feb. 18.) 2300 w.

*10621. The Mystery of Steam. Letters of Robert Mansell and William Donaldson (Eng L-Feb. 10.) 2000 w.

10705. Some Thoughts on Boiler Inspection. John Hickey (R G-Feb. 24.) 1400 w.

10762. The Steam Engine Indicator, Applied to an Unevenly Balanced Engine (B J C-Feb. 25.) 650 w.

10763. Boiler Feed Pipes (B J C-Feb. 25.) 1000 w.

10764. Steam Power's Discoverer.—The Painful Story of Samuel Caus (B J C-Feb. 25.) 600 w.

*10790. Winding Engines (C G-Feb. 17.) 1800 w.

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10879. Deterioration of Condenser Tubes in the United States Steamship "Baltimore" (Ir Age-March 2) 1800 w.

10886. Waste Steam Injectors. W. H. Booth (A M-March 2.) 1300 w.

*10910. Heat and Combustion. Angus Sinclair (L E-March.) 2800 w.

*10916. Manipulating Boiler Plates (L E-March.) 900 w.

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10950. The Strength of Shafting (B J C-March 4.) 1200 w.

10951. Steel Boiler Tubes.—Will They Supersede Iron? (B J C-March 4.) 700 w.

10952. A Corliss Valve Trouble. Ill. (B J C-March 4.) 500 w.

10972. Sequence of Cylinders and Cranks in Triple Expansion Marine Engines. W. J. Winterburn (Eng-March 4.) 1500 w.

11071. Injector Notes—Ejector Condensers. W. H. Booth (A M-March 9.) 1500 w.

Serials.

7456. The Locomotive Boiler. Ill. Gustav Richard (A J R A-Began Oct.—4 parts to date—30 cts. each).

10664. Apparatus for Determining the Amount of Water in Steam. W. R. Cummins (I L-Began Feb. 10—Ended Feb. 17—2 parts—30 cts. each).

10681. Compound Expansion Engines (Ir Age-Began Feb. 23—1 part to date—15 cts).

10726. The Development of the Steam Engine (M R C-Began Feb. 23—2 parts to date—15 cts. each).

10946. Hints. W. H. Wakeman (M G-Began March 4—1 part to date—15 cts).

11001. Thermodynamic and Adiabatic Diagrams of Water and Steam. Ill. R. H. Smith (I L-Began Feb. 24—1 part to date—30 cts).

11085. The Causes of Corrosion in Steam Boilers. William H. Edgar (S E-Began March 4—1 part to date—15 cts).

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10512. The Crowning Achievements of the Telephone (Sc A-Feb. 18.) 1000 w.

10519. The Death of Dr. Norvin Green. Ill. (E W-Feb. 18.) 800 w.

*10529. One Use for the Telephone. Ill. F. S. Marsh (E E L-Feb. 3) 900 w.

10649. The Berliner Microphone Patent. Editorial (Sc A-Feb. 25.) 1400 w.

10680. The Submarine Cable Systems of the World (Ir Age-Feb. 23) 1000 w.

10702. Berliner Telephone Litigation. Editorial (W E-Feb. 25.) 2800 w.

*10768. The Latest Telegraph Statistics (E L-Feb. 17.) 400 w.

10819. The Telephone.—Its Legal History and Commercial Condition Presented by a Master Hand. Grosvenor P. Lowry (E R N Y-Feb. 25.) 3500 w.

10822. Telephone Improvement (E R N Y-Feb. 25.) 950 w.

*10828. The Chin Column Telegraph Expedition. F. E. Dempster (E R L-Feb. 17.) 4200 w.

10839. The Famous Bell Patent. Ill. (E R N Y-March 4.) 3000 w.

*11051. An Improved Telephone Switchboard System. Ill. (E R L-Feb. 24.) 1100 w.

Serials.

6515. Notes on Submarine Cable Work. Ill. H. D. Wilkinson (El-Began Sept. 2—Ended Feb. 17--10 parts--30 cts. each).

10285. Inaugural Address of W. H. Preece (E E L-Began Jan. 27—Ended Feb. 3—2 parts —30 cts. each).

10470. The Theory of Submarine Cable Laying. G. W. Littlehales (E E N Y-Began Feb. 15—Ended Feb. 22—2 parts—15 cts. each).

10669. The Telephone Situation (E W-Began Feb. 25—2 parts—15 cts. each).

MISCELLANEOUS.

*10501. A Decade of Marvelous Progress. R. H. Edmonds (E Mag-April.) 3000 w.

*10506. Refrigeration from Central Stations. John E. Starr (E Mag-April.) 3000 w.

*10507. Conditions of Forestry as a Business. W. J. Beal (E Mag-April.) 3000 w.

*10508. An Early Engineering Magazine. Hyland C. Kirk (E Mag-April.) 3000 w.

*10509. The Past and Future of Engineering. Gordon B. Kimbrough (E Mag-April.) 3000 w.

10515. Motors for Aerial Machines. Abstract from a Lecture by O. Chanute (Sc A S-Feb. 18.) 2500 w.

10522. Will We Navigate the Air? Ill. Hiram Maxim (S V-Feb. 15.) 3000 w.

†10581. Commercial Unity with the Colonies. Augustus Loftus (N C-Feb.) 3000 w.

*10617. Municipal Contracts. Alfred H. Gibbings (E R L-Feb. 10.) 1600 w.

*10626. The Wiborgh Luft (Air) Pyrometer. Emanuel Trotz (C G-Feb. 10.) 1500 w.

10655. Attacks on City Parks (G & F-Feb. 22.) 1200 w.

*10685. The Onyx Deposits of Cave Creek, Arizona. George P. Merrill (S-Feb.) 700 w.

10699. The Art of To-day. C. F. A. Voysey (A & B-Feb. 25.) 2200 w.

†10719. The Science of Municipal Corruption (F-March.) 4000 w.

†10722. An Appeal to Retire Government Paper Money. M. Brühl (F-March.) 2200 w.

*10732. In Our Cotton Belt. Ill. H. S. Fleming (Cos-March.) 4500 w.

*10734. An Italian Campo Santo. Ill. Murat Halstead (Cos-March.) 3500 w.

10754. The Status of the Engineering Profession. H. F. J. Porter (E R-Feb. 25.) 900 w.

10760. Brief Historical Review of the Lakes and Gulf Waterways. J. R. Leighty (R T-Feb.) 1200 w.

10777. The Downfall of the Hawaiian Monarchy. William T. Brigham (B C-Feb. 25.) 1800 w.

*10796. On Pottery Glazes: Their Classification and Decorative Value in Ceramic Design. Ill. Wilton P. Rix (J S A-Feb. 17.) 1300 w.

*10805. The Commercial Aspect of an Engineer's Training. Editorial (E-Feb. 17.) 1200 w.

*10809. The Future of Sculpture (A L-Feb. 17.) 2000 w.

†10850. American Farming A Hundred Years Hence. J. M. Rusk (N A R-March.) 2800 w.

†10851. The Sandwich Islands.—I. The Advantages of Annexation. Lorrin A. Thurston. II. Is It Constitutional? George Ticknor Curtis (N A R-March.) 8200 w.

†10852. Modern Insurance and Its Possibilities. R. A. McCurdy, J. L. Greene, Sheppard Homans, and Clarence H. Kelsey (N A R-March.) 7200 w.

†10854. England in the Orient. Arminius Vambéry (N A R-March.) 2000 w.

†10855. National Banking and the Clearing House. A. B. Hepburn (N A R-March.) 4200 w.

*10856. America in Hawaii. Ill. Sereno Bishop (R of R-March.) 4800 w.

*10857. England in Egypt. Ill. (R of R-March.) 6300 w.

10867. The Manufacture of Dynamite. Ill. Maxime Vuillaume (Sc A-March 4.) 2000 w.

10876. The Principles of Economic Legislation. Edward A. Ross (P A-March 1.) 1600 w.

*10896. The Recent Survey in St. Louis.—Its Methods and Results. Ill. B. H. Colby (J A E S-Jan.) 14,000 w.

10904. Asphalt Pavements.—How They Should Be Cleaned (E N-March 2.) 2600 w.

10919. Some Causes of Failure of Heating

Apparatus. Franklin Van Winkle (A Ar–March 4.) 1700 w.

10925. The Fuel Question. Editorial (A M & I W–March 3.) 1000 w.

10937. "The Status of the Engineering Profession." Peter Milne (F W–March 4.) 900 w.

10941. Test of a Hot Water Heating Plant. Ill. (E R–March 4.) 3000 w.

10947. Value of Spruce Forests. Editorial (M G–March 4.) 1100 w.

10948. The Distinction Between the Patent Systems of the United States and Those of Other Countries. A. Steuart (I Age–March.) 3800 w.

10949. On the Wing.—Imitation of Birds and Insect Flight. Ill. Si. O. Bud (I Age–March.) 500 w.

10953. The Fuel Oil Plant at the Columbian Exposition. Ill. (P S–March.) 2200 w.

11011. Engineering Progress. Alfred E. Hunt (R R–March 4.) 1600 w.

11014. Perpetual Motion Infatuation. Editorial (M R–March 3.) 900 w.

11030. Carelessness in Pipe Fitting (Met W–March 4.) 3500 w.

11032. An Aboriginal Soapstone Quarry (M & B–Feb.) 1000 w.

11095. The Use of Burlap for Levee Protection During High Water. E. J. Chamberlain (E N–March 9.) 800 w.

Serials.

9401. World's Columbian Exposition (E N–Began Jan. 5—3 parts to date—15 cts. each).

9519. Municipal Equipment and Engineering of Paris Jas. W. Howard (P–Began Jan.—Ended. March—3 parts—30 cts. each).

9745. American Industries and British Commerce (E–Began Jan. 6–6 parts to date—30 cts. each).

9851. The Glass Industry. Ill. C. Hanford Henderson (P S M–Began Feb.—Ended March—2 parts—45 cts. each).

10490. The Diffusion of Light. W. E. Sumpner (El–Began Feb. 3—Ended Feb. 17—3 parts—30 cts. each).

10535. Notes from the Engineering Schools (E N–Began Feb. 16—3 parts to date—15 cts. each).

NEW BOOKS OF THE MONTH.

(For the convenience of readers any American books will be supplied at publishers' prices by The Engineering Magazine Co. Foreign books, 25 per cent. extra.)

Abbe, Cleveland.=The Mechanics of the Earth's Atmosphere: A collection of translations. Washington, D. C.: Smithsonian Institution. [Paper, 327 p.]

Bankson, Lloyd.=Slide-Valve Diagrams: A French Method of Obtaining Slide-Valve Diagrams. New York: D. Van Nostrand Co. [16mo, boards, 50c.]

Baye, J. de.=The Industrial Arts of the Anglo-Saxons: From the French, by T. B. Harbottle. New York: Macmillan. [Folio, cloth, 181 p., $7.]

Bedell, Frederick, and Crehore, Albert C.= Alternating Currents: An Analytical and Graphical Treatment for Students and Engineers. New York: W. J. Johnston Co. [8vo, 325 p., $2.50.]

Bonney, G. E.=Electrical Experiments: A Manual of Instructive Amusement. New York: Macmillan. [12mo, cloth, 265 p., 75c.]

Bottone S. R.=How to Manage the Dynamo: A handbook for ship engineers, electric light engineers, and electro-platers. New York: Macmillan. [12mo, cloth, 65 p., 60c.]

Gilbert, W.=On the Lodestone and Magnetic Bodies, and on the Great Magnet of the Earth: a translation by P. Fleury Motlelay. New York: Wiley. [8vo, cloth, 384 p., $4.]

Gray, Andrew.=The Theory and Practice of Absolute Measurements in Electricity and Magnetism. New York: Macmillan. [12mo, cloth, $6.25.]

Hett, C. L.=The Turbine Manual and Millwright Handbook. New York: Spon. [8vo, paper, 80c.]

Hiles, Theron L.=The Ice Crop: how to harvest, store, ship, and use ice. New York: Orange Judd Co. [12mo, cloth, 125 p., $1.]

Infantry Drill Regulations, U. S. Army;—With Interpretations of 250 Pars.: by the Recorder of the Tactical Board. New York: Army and Navy Journal. Appleton. [32mo, paper, 398 p., 30c.]

Jeffrey Manufacturing Co., Columbus, O.= Elevating and Conveying Machinery. A new catalogue for 1893, elaborately illustrated and so replete with tabulated statistics and practical information that it may rightly be called a textbook covering the whole broad field. [8vo, paper, 260 p., free on application to the firm.]

Kundsen, Augustus. = Triangular Surveys from Single Stations. San Francisco: Brunt & Co. [32mo, paper, 32 p., $1.]

La Rue, B. F.=A Graphical Method for Swing-Bridges. New York: D. Van Nostrand Co. [16mo, boards, 50 cts.]

Nasmith, Jos.=Students' Cotton Spinning. New York: D. Van Nostrand Co. [12mo, cloth, $3.]

Reece, Benjamin.="Railway Specialties." Vol. I. No. 1. A humorous periodical, modeled after "Life"; elaborately and takingly illustrated, and designed for the entertainment of railroad men, while at the same time making known the virtues of certain railway appliances. An original and striking publication which every railroad man should possess. [Sent free on application. The Q. & C. Co., Chicago–New York.]

Water Tower, Pumping and Power Station Designs: The Engineering Record's 34 Prize Designs. [4to, cloth, $2.]

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